THE ELECTRONICS MAGAZINE WITH THE PRACTICAL APPROACH

March 1990

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Elektor Electronics

Sinewave inverter

Surge plug

Pause switch for camcorders

Powerline monitor

Temperature compensation for LCD modules

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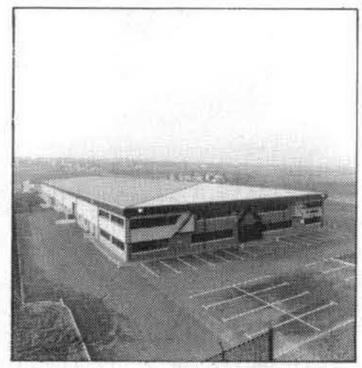
Front cover

Molecular electronics will be as different to today's electronics as semiconductors are from the valve technology of 40 years ago. This is the belief of scientists who are now working on a £20 million programme in Britain, backed by the Department of Trade and Industry's Link Programme of collaborative research between universities and industry.
One familiar example of molecular electronics in use today is the liquid crystal display seen in watches and calculators–and even head-up displays for pilots–that respond vigorously to electrical or heat signals.
Here, scientists at Imperial College, London, are working on a project to build new types of 'molecular' switches for use in waveguides. In the field of conventional electronics, electrons flow through wires and devices like simple transistor switches. In the optical equivalent, light travels down planar optical waveguides through 'molecular' switches. These switches can be made by coating glass substrates with a special polymer. In the picture it is being studied with a new technique known as time-resolved evanescent wave-induced fluorescence spectroscopy.

We regret that owing to legal restrictions we can not publish "SAVE decoder – Part 2" as planned. At the same time, supply and design difficulties have made it necessary to postpone "Sinewave inverter"; no new date can as yet be given for its publication.



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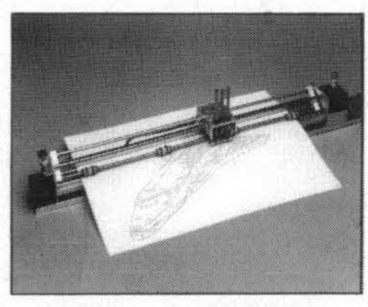

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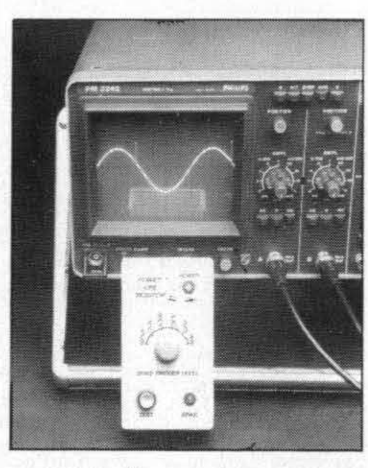

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INTERMEDIATE PROJECT

A series of projects for the not-so-experienced constructor. Although each article will describe in detail the operation, use, construction and, where relevant, the underlying theory of the project, constructors will, none the less, require an elementary knowledge of electronic engineering. Each project in the series will be based on inexpensive and commonly available parts.

9. IC MONITOR

J. Ruffell

Digital probes come in many shapes and versions. All of these, however, suffer from a single disadvantage: they can monitor the logic level at only one IC pin at a time. To overcome this limitation, we propose a 16-way IC monitor with a probe that can be clipped on to virtually any commonly used logic dual-in-line integrated circuit with up to 16 pins. Ideal for getting to grips with digital circuits, this IC monitor gives an instant indication of all input and output levels simultaneously. Interestingly, it automatically finds the power pins of the IC under test and works with most TTL and CMOS circuits.

The circuit of the IC monitor (Fig. 1) consists of 16 identical smaller circuits powered by one supply. The operation of the input circuits will be described with reference to the top one, which consists of D_{17}-D_{18}-R_{18}-N_6-R_2-D_{16}.

The IC monitor is powered by the circuit under test via the two supply pins of the IC it is connected to. This means that the power supply of the circuit under test must be capable of supplying an additional current of up to 500 mA to power the IC monitor. Make sure this is the case before connecting the monitor!

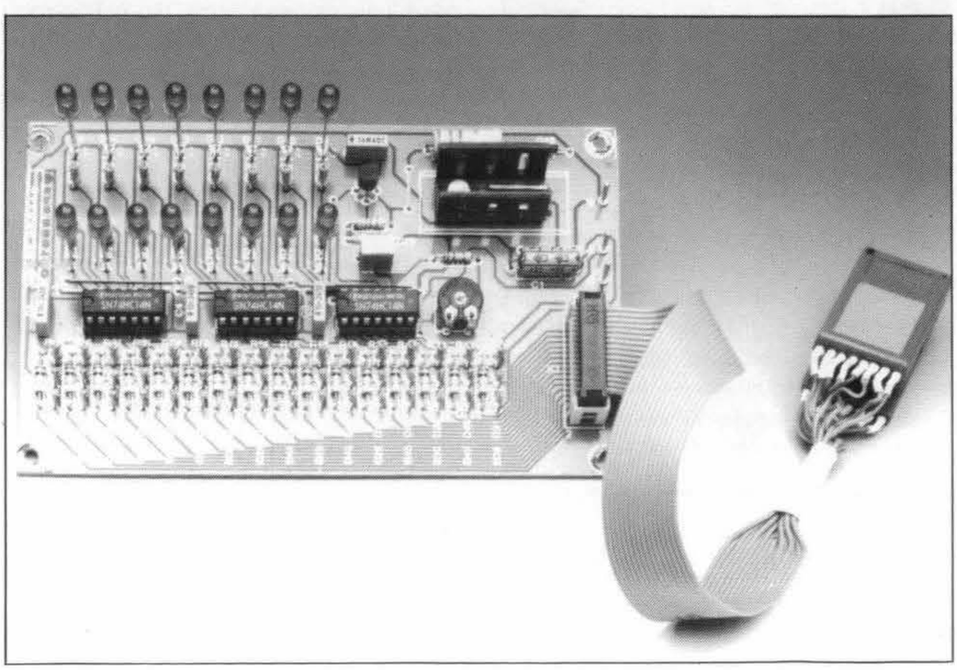
You are probably aware that pin 14 of 14-way DIL logic ICs is usually the positive supply terminal, and pin 7 the ground terminal. For 16-way ICs, the respective pins are usually 16 and 8. Unfortunately, there are also many ICs which deviate from this rule of thumb —their power connections are at pins other than 14 or 16, and 7 or 8. The IC monitor, however, finds the power pins automatically. How? Let's examine the input circuit a little closer.

If a valid logic level is measured at pin 2 of connector K_1, it will be either a 1 or a 0. Whichever, the absolute voltage is invariably a little lower (for a 1) than the positive supply voltage, or a little higher (for a 0) than 0 V. This is because the swing of logic IC outputs is nearly always smaller than their supply voltage owing to the forward drop across the output transistor(s). Invariably, only two of the diodes D_{17}–D_{48} will therefore conduct and pass the supply current because they are the ones connected to the highest potential —the supply voltage.

On the above assumption that pin 2 of K_1 carries a logic level and not the positive or negative supply voltage, diodes D_{18} and D_{17} block, but the monitor circuit is powered by two other diodes. The logic level is applied to the input of inverter N_6 via series resistor R_{18}. Depending on the measured logic level, the inverter supplies either a low output level (input = high), or a high output level (input = low). Hence, the LED at its output, D_{16}, lights only if the measured level is high (1).

TTL and CMOS

There are a large number of significant differences between ICs from the TTL



(transistor-transistor logic) and the CMOS (complementary metal-oxide silicon) family. The most important difference is the supply voltage range of about 4.5–5.25 V for TTL circuits against about 3–18 V for most CMOS ICs (note: there are many exceptions to this rule).

Since the IC monitor is to be suitable for use with TTL as well as CMOS ICs, it would appear logical to use CMOS inverters from the well-known CD4000 series, since these have the larger supply voltage range. Unfortunately, the outputs of these ICs can not sink enough current to drive a LED direct. The alternative, 16 discrete current amplifiers, must be rejected because it would require a quite complex circuit. There is, however, an IC family capable of working at relatively low supply voltages **and** sinking the current required to light a LED: the 74HC series.

The one disadvantage of the 74HC series, the maximum supply voltage of about 6 V, is fairly simple to overcome by using a series regulator which limits the supply voltage taken from the circuit under test to a value which is safe for the inverters in the IC monitor. This regulator is a discrete circuit, R_{51}-D_{50}-T_2. Before its limiting action starts, the output voltage of the series regulator follows the input voltage quite accurately, which is an important requirement for 5-V digital systems.

Circuit T_1-R_{50}-D_{49} forms a voltage source which limits the LED current(s) to an acceptable level at relatively high supply voltages. Let's assume that the circuit under test works at a supply voltage of 12 V, and that the voltages across D_{17} and D_{18} are about 2 V. Without T_1, the series resistor for the LED would have to drop about 10 V. Similarly, for a system operating at 5 V, the drop would work out at about 3 V, which evidently requires another resistor value. The solution to this problem has been found in the use of a series resistance, T_1, whose value increases automatically with the supply voltage. Since T_1 limits the LED voltage to about 2 V, a single resistor value (22 Ω) may be used for the full range of the supply voltage.

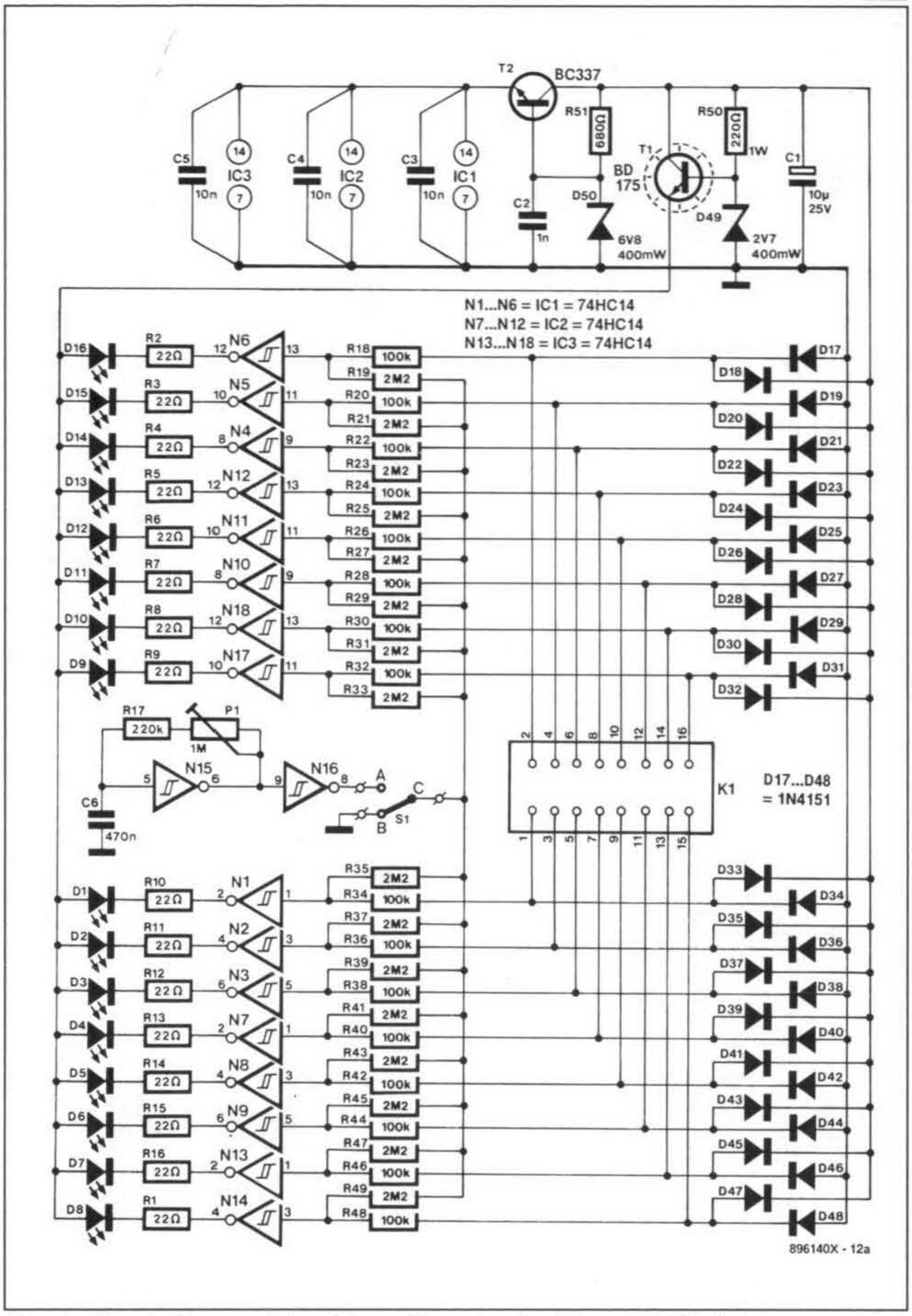


Fig. 1. Circuit diagram of the 16-input IC monitor for TTL and CMOS digital circuits.

Open input?

In general, inputs of CMOS ICs must never be left open. You may have found out already from experiments that an open (non-connected) CMOS input causes the IC to heat up and destroy itself rapidly. The actual destruction is normally caused by excessive current drawn by the output stages. Obviously, this effect must be avoided at all times and calls for an additional function of the IC monitor: detection of open CMOS inputs.

The circuit to do so is an oscillator, N_{15}-N_{16}-R_{17}-P_1-C_6. When switched on with S_1, it supplies alternating low and high levels to the inverter gates via 2.2 MΩ resistors. When the oscillator is switched off, these resistors ensure well-defined low levels at the inverter inputs that do not receive a logic signal from the circuit under test. The high resistor value of 2.2 MΩ ensures at the same time that measured signals do not see an additional load, so that the inverters can follow the high and low levels reliably.

Finally, note the type of diode in positions D_{17}–D_{48}: the 1N4151 is used rather than the perhaps more familiar 1N4148 because of its lower forward voltage drop, which is essential for correct operation of the circuit.

Construction

Since the circuit is quite complex by the standards used in this series of articles, it is best to build the IC monitor on the printed-circuit board shown in Fig. 2. This board is available ready-made through the Readers Services. For those with access to a photographic dark-room and the necessary etching and drilling equipment, the mirror image of the track side of the circuit board is shown to enable a transparent film to be made from a photocopy.

Since the pad density is fairly high in places, the PCB must be soldered with great care and precision. Work accurately and use a low-power iron and little solder to prevent short-circuits between adjacent tracks and pads.

Start the population with the wire links. Next, fit the passive parts (capacitors, resistors, IC sockets, the preset and the pin header). Lastly, mount the transistors and the diodes (but not the LEDs), taking good care to maintain the correct orientation.

The power transistor, T_2, is fitted with a small U-shaped heat-sink (TO-220 style) to assist in its cooling. The heat-sink is bolted on to the board together with the transistor. An insulating washer is not re-

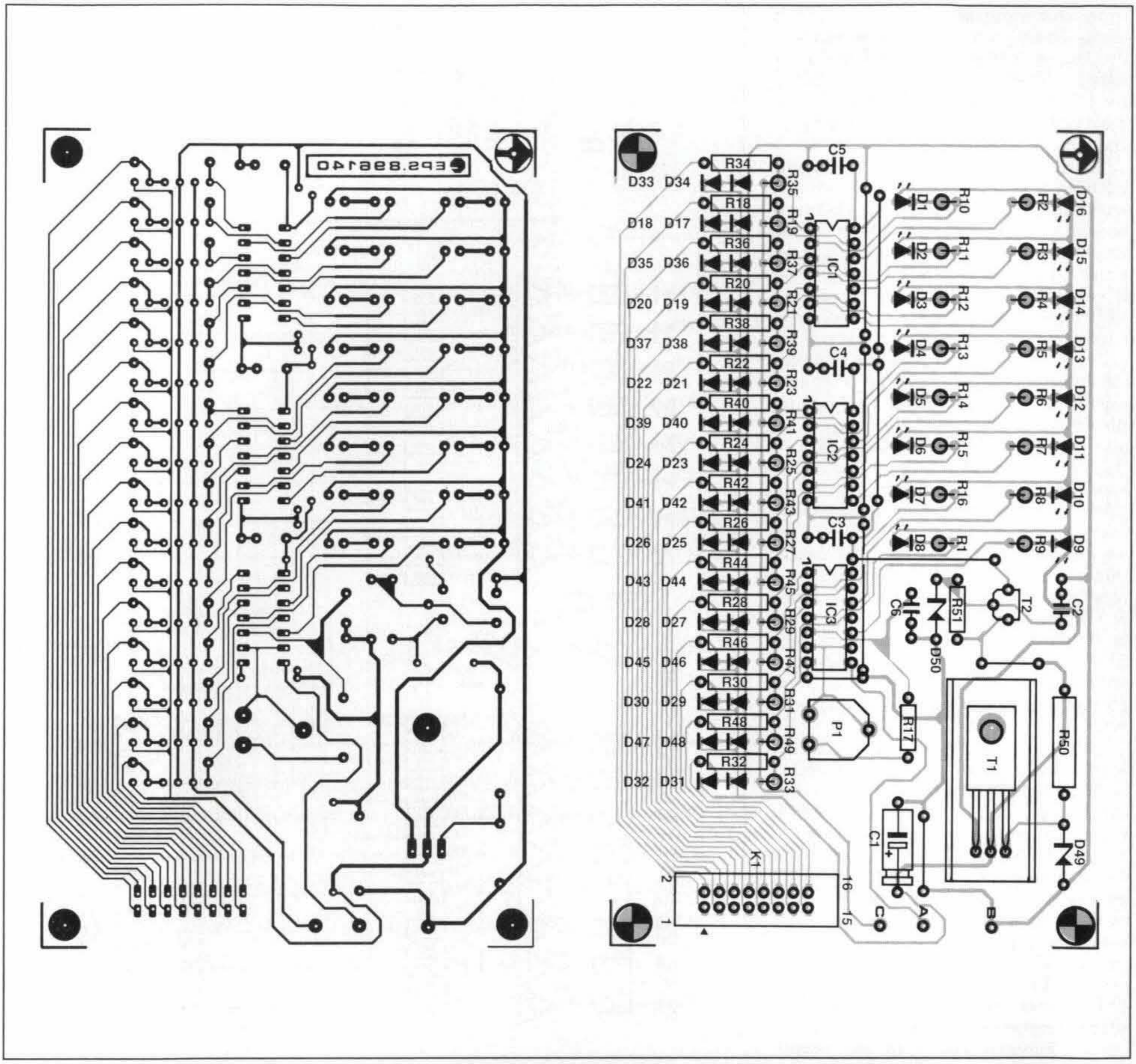


Fig. 3. Track lay-out (reflected) and component mounting plan of the printed-circuit board for the IC tester.

quired. Be sure to leave the terminals of the BD175 long enough so that they can be bent at right angles for inserting into the PCB holes without touching the heat-sink.

Next, mount each LED such that the lower side of its plastic body is about level with the top of the heat-sink. Do not fit the completed PCB into the enclosure as yet.

Initial test

Use a pair of light-duty flexible test leads with small crocodile clips to connect a DC power supply of 5–18 V to any two pins of connector K_1. Set P_1 to the centre of its travel. Set switch S_1 to position B (inverter inputs logic low). If the circuit works so far, the LED associated with the pin connected to the positive supply voltage will light. Set S_1 to position A (oscillator on) and check that 14 LEDs flash. Adjust P_1 for the required flash rate. Next, systematically connect the positive and negative

COMPONENTS LIST

Resistors:
R_1–R_{16} = 22Ω
R_{17} = 220k
R_{18};R_{20};R_{22};R_{24};R_{26};R_{28};R_{30};R_{32};R_{34};R_{36};R_{38};
R_{40};R_{42};R_{44};R_{46};R_{48} = 100k
R_{19};R_{21};R_{23};R_{25};R_{27};R_{29};R_{31};R_{33};R_{35};R_{37};R_{39};
R_{41};R_{43};R_{45};R_{47};R_{49} = 2M2
R_{50} = 220Ω 1 W
R_{51} = 680Ω
P_1 = 1M0 preset H

Capacitors:
C_1 = 10µ;25 V
C_2 = 1n0
C_3;C_4;C_5 = 10n
C_6 = 470n

Semiconductors:
D_1–D_{16} = LED; red; 5-mm dia.
D_{17}–D_{48} = 1N4151
D_{49} = 2V7; 400 mW zener diode
D_{50} = 6V8; 400 mW zener diode
IC_1;IC_2;IC_3 = 74HC14
T_1 = BD175
T_2 = BC337

Miscellaneous:
S_1 = miniature toggle switch.
K_1 = 16-way angled pin header for PCB mounting.
K_2 = 16-way IDC socket.
K_3 = 16-way IC test clip (e.g., ElectroMail stock number 423-627).
TO-220 or TO-126 style heat-sink.
Approx. 50 cm 16-way flatcable.
PCB Type 896140 (see Readers Services page).

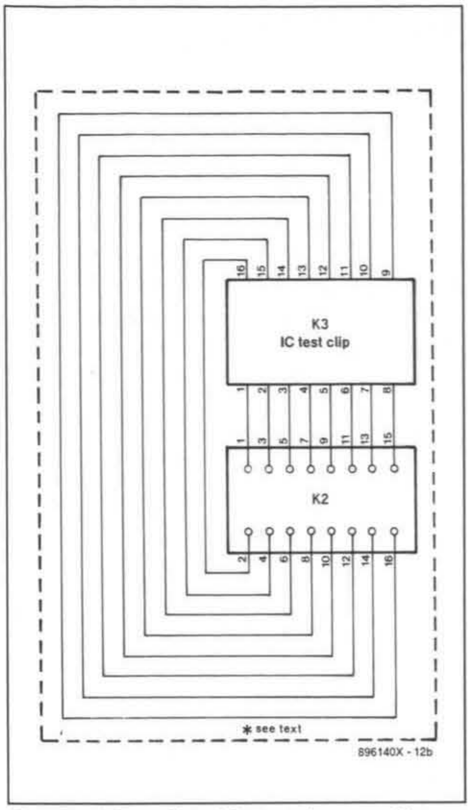


Fig. 3. Test clip wiring and connections.

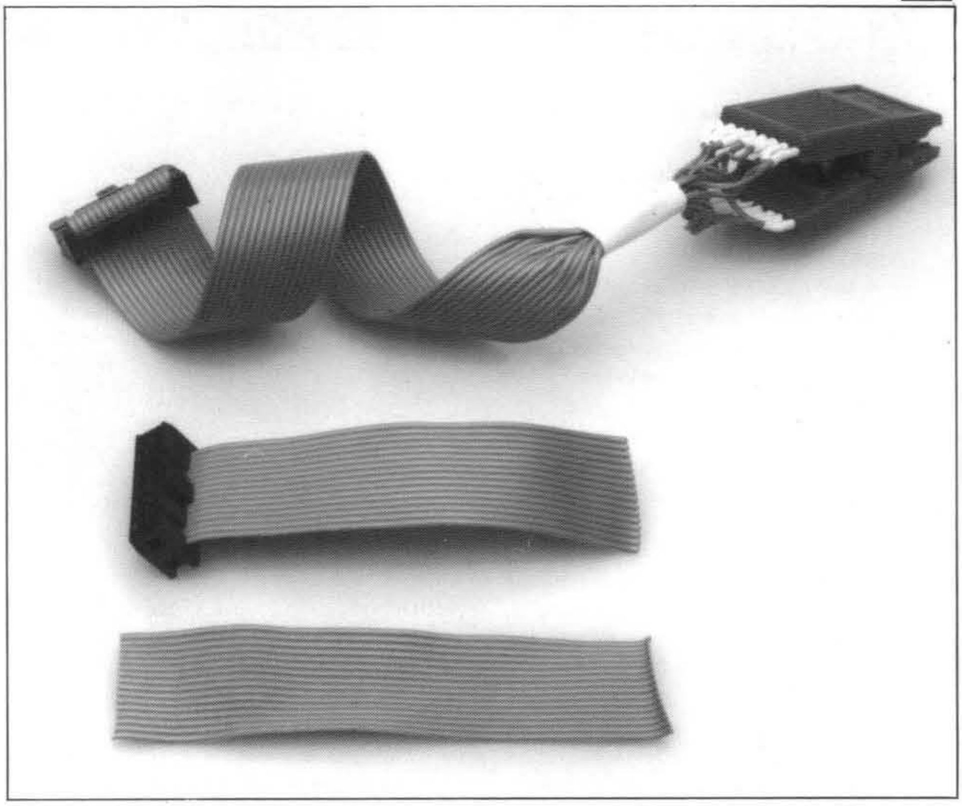


Fig. 4. The test cable is made from an IDC, a length of flatcable and a 16-way IC test clip.

supply wires to all other inputs to verify the operation of the associated diodes (e.g., pair D_{17}-D_{18} for K_1 pin 2).

Case and test cable

The completed, tested and adjusted printed-circuit board is fitted in a suitably sized ABS enclosure, for which a suggested front-panel lay-out is given in Fig. 5 (ready-made front panel adhesives are not available). Cut a rectangular slot in one of the short sides of the enclosure to enable an IDC (insulation displacement connector) to be connected to K_1.

The construction of the 16-way flatcable between the IC monitor and the test clip is illustrated in Fig. 4. Contrary to what many electronics retailers and connector manufacturers would have you believe, an IDC is fairly simple to fit on to a flatcable of almost any width, without the use of special (very expensive) tools.

Cut the cable as straight as you can using a large pair of scissors. Insert it between the socket (or header) and the associated cap, taking care to align the individual wires in the cable with the V-shaped clamps which are to receive them. Note the position of pin 1 on the connector, which is usually marked. Make sure this pin is at the side of the single coloured wire in the flatcable.

Most IDCs have a U-shaped cap with snap-in fittings on the side guides, which readily lock with the main connector. Carefully place the cap on the socket, pressing it down with equal force at both extremes to prevent one guide locking before it is due. Use hand force to clamp the flatcable between the socket and the cap. Check whether the flatcable and the socket are at right angles. Next, use a small piece of wood and a light hammer, or a carefully operated vise, to press the cap further on to the socket until the parts click together. Apply a little more force to ensure a good connection. Some IDCs have an additional cap that functions as a strain relief. Fold the flatcable back and fit this second cap.

Connect the pins of the 16-way IC test clip to the corresponding wires at the other side of the flatcable. Be sure to connect the flatcable wires to the same pin numbers as K_1 (K_1 pin 1 goes to test clip pin 1, etc.). Finally, use an ohmmeter or a continuity tester to check whether all connections are in accordance with the circuit diagram.

Practical use

No doubt you will soon find the IC monitor an indispensable and easy-to-use test instrument for a wide variety of digital circuits. Open inputs are traced rapidly by switching S_1 to the oscillator position. Any one LED which starts to flash in addition to already flashing ones indicates an open input (remember that slowly changing logic levels applied to the IC may cause LEDs to flash if the oscillator is switched off with S_1). If the frequency of a measured logic level exceeds about 25 Hz, the relevant LED no longer flashes, but appears to light at reduced intensity. Finally, make a habit of switching off the circuit under test before placing the clip on an IC. ■

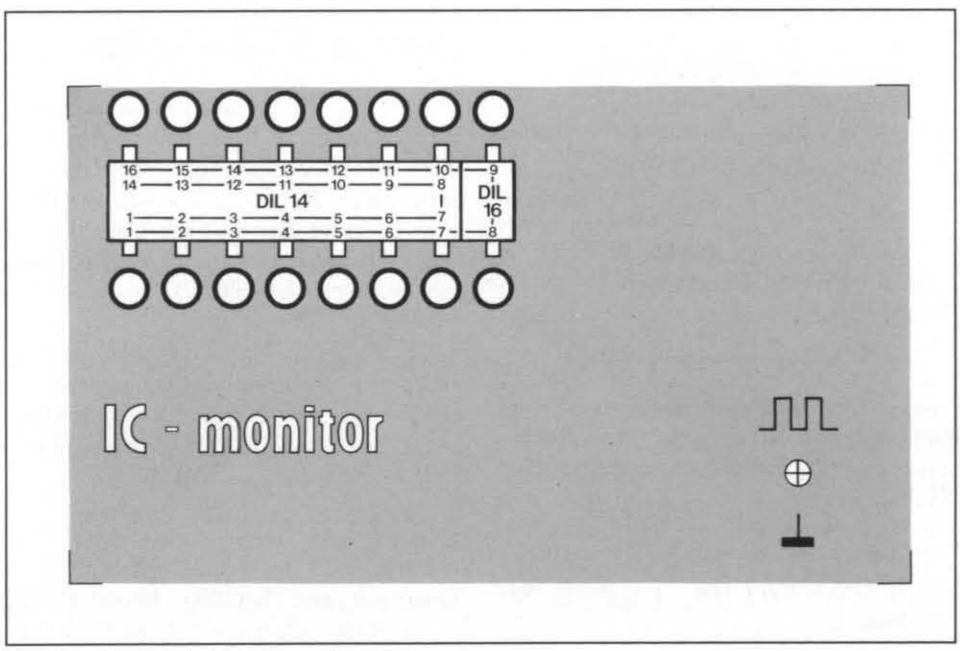
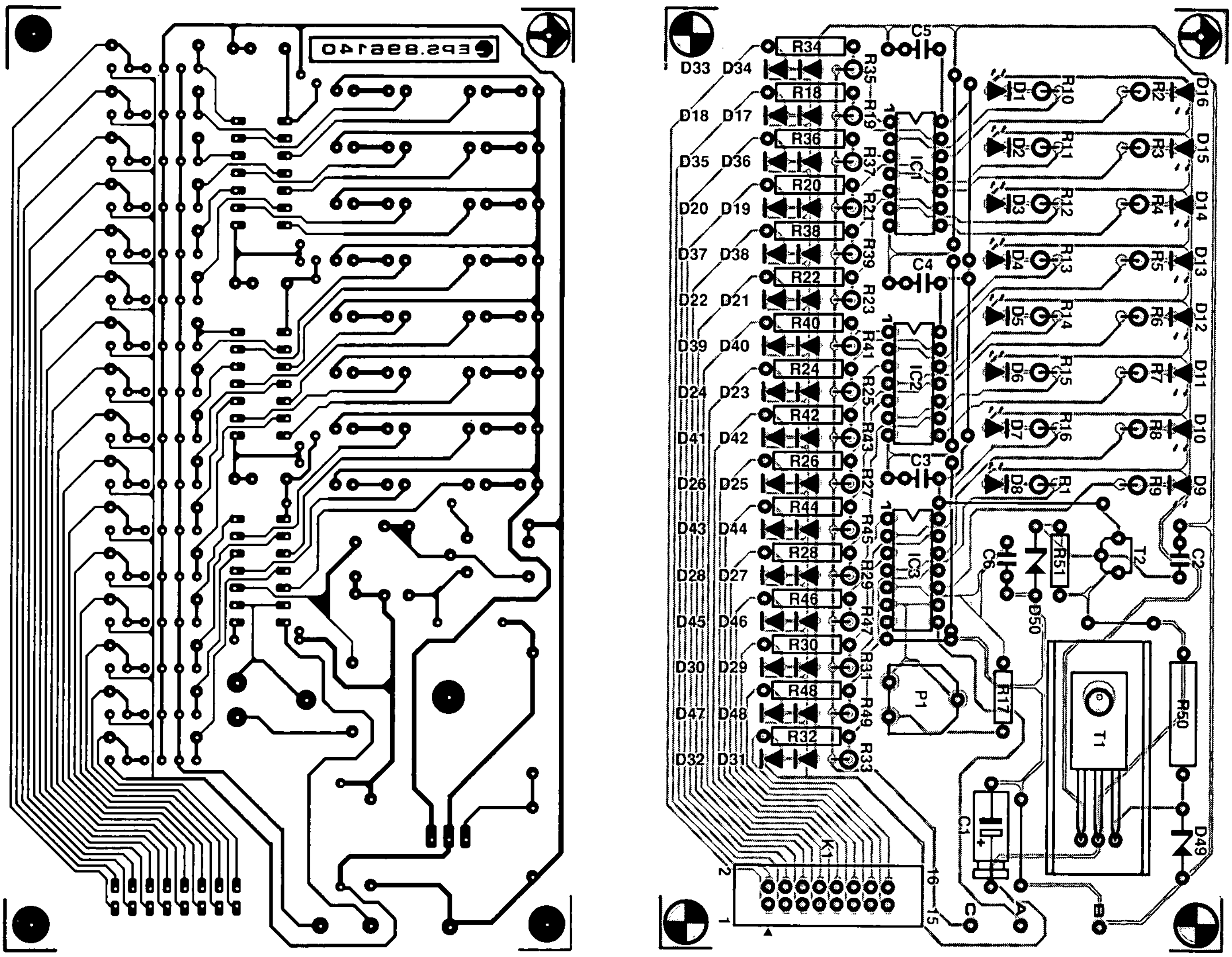


Fig. 5. Suggested front-panel lay-out.



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R_{50} = 220Ω 1 W
R_{51} = 680Ω
P_1 = 1M0 preset H

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C_2 = 1n0
C_3;C_4;C_5 = 10n
C_6 = 470n

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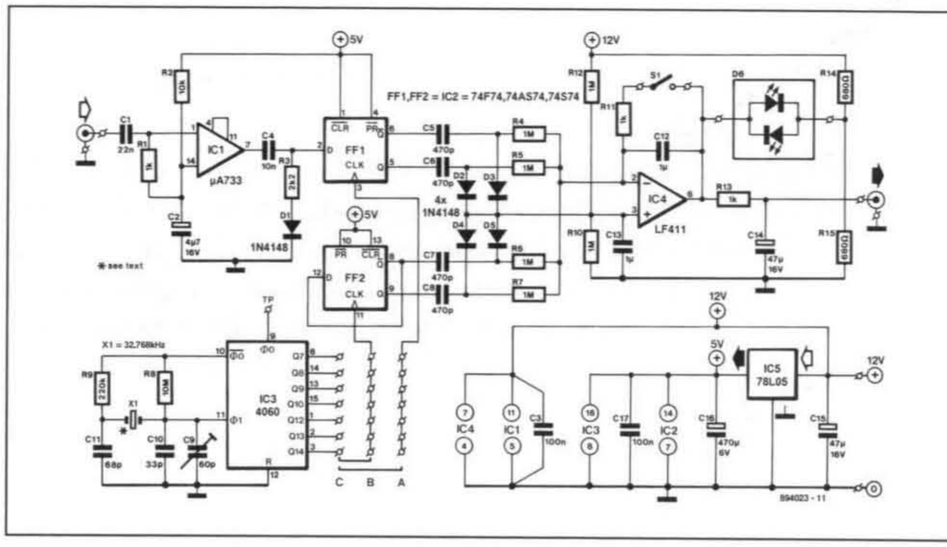
TO-220 or TO-126 style heat-sink.
Approx. 50 cm 16-way flatcable.
PCB Type 896140 (see Readers Services page).

VFO STABILIZER



The stabilizer presented here enables the precise tuning of HF oscillators for up to 100 MHz if these have a frequency control input. That input is normally used for varying the capacitance of a varactor.

The signal at the input of the circuit is amplified by a fast operational amplifier, IC_1. The output of this opamp is a rectangular signal that is applied to the D (data) input of bistable FF_1. The clock input of the bistable is provided by generator IC_3. The two outputs of the bistable are the product of the clock and the input signal. The frequency of this composite signal lies between 0 Hz and half the clock frequency. To ensure the best possible control characteristic, the output signal of the bistable is compared with a reference signal that has a frequency one quarter of the clock. To that end, a second bistable, FF_2, is connected as a binary scaler; its input is provided with a signal whose frequency is half that of the clock applied to FF_1.

The differentiating network at the output of FF_1 uses only the negative pulses of the output signal, whereas that at the output of FF_2 uses only the positive pulses. All these pulses are combined in an integrator, resulting in a stable control voltage. Since both the Q and the $\overline{Q}$ output are used, the ripple is halved.

If the frequency of the input signal is not stable, the amplitude of the integrated signal varies. The variations are used to control the oscillator in a manner where the deviations are negated.

The clock is constructed around a CD4060 and an inexpensive watch crystal. The crystal may, of course, be replaced by a different type, as long as this has the required stability.

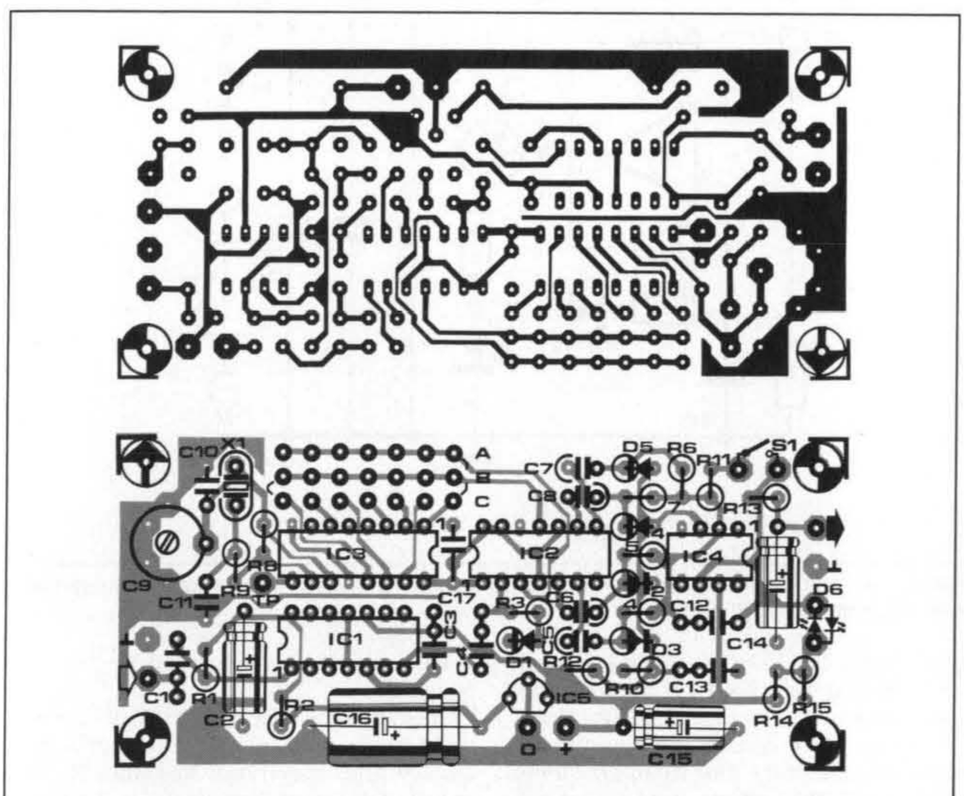
The clock frequency, and thus the required grid, is set with the aid of jump leads. The frequency on row B must always be half that on row A.

The construction and alignment should not present any undue problems if the circuit is built on the PCB shown below. The oscillator is set to exactly its centre frequency by C_9: this can be verified at test point TP, which carries the buffered clock frequency.

The circuit is powered by a 12-V supply that is brought down to 5 V and stabilized by regulator IC_5.

Indicator D_6 remains out as long as long as the oscillator frequency is stable. If the frequency drifts, the lED lights, its colour and intensity indicate in what direction drift occurs and how serious the drift is.

The integrating action may be disabled by S_1, which allows the circuit to settle down more rapidly than with it on. ■



COMPONENTS LIST

Resistors:

3	1k	R_1;R_{11};R_{13}
1	10k	R_2
1	2k2	R_3
6	1M0	R_4–R_7;R_{10};R_{12}
1	10M	R_8
1	220k	R_9
2	680Ω	R_{14};R_{15}

Capacitors:

1	22n ceramic	C_1
1	4µ7 16V	C_2
1	100nF ceramic	C_3
1	10nF ceramic	C_4
4	470pF polystyrene	C_5–C_8
1	60pF trimmer	C_9
1	33pF	C_{10}
1	68pF	C_{11}
2	1µ0 MKT	C_{12};C_{13}
2	47µF 16V	C_{14};C_{15}
1	100nF MKT	C_{17}

Semiconductors:

5	1N4148	D_1–D_5
1	bicolour LED	D_6
1	uA733	IC_1
1	74F74 or 74S74 or 74AS74	IC_2
1	CD4060	IC_3
1	LF411	IC_4
1	78L05	IC_5

Miscellaneous:

1	SPST switch	S_1
1	crystal 32.768 kHz	X_1
1	PCB	894023

VFO STABILIZER

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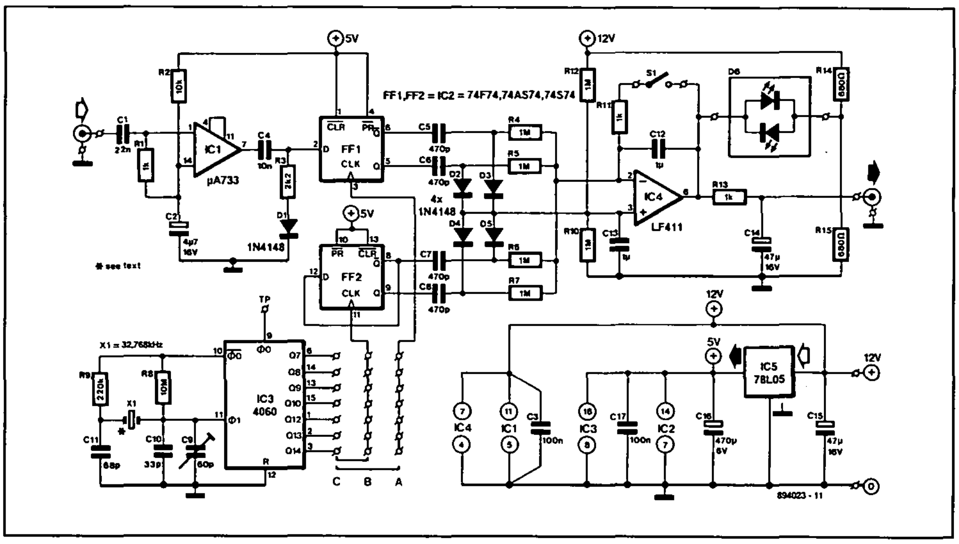
The signal at the input of the circuit is amplified by a fast operational amplifier, IC1. The output of this opamp is a rectangular signal that is applied to the D (data) input of bistable FF1. The clock input of the bistable is provided by generator IC3. The two outputs of the bistable are the product of the clock and the input signal. The frequency of this composite signal lies between 0 Hz and half the clock frequency. To ensure the best possible control characteristic, the output signal of the bistable is compared with a reference signal that has a frequency one quarter of the clock. To that end, a second bistable, FF2, is connected as a binary scaler; its input is provided with a signal whose frequency is half that of the clock applied to FF1.



The differentiating network at the output of FF1 uses only the negative pulses of the output signal, whereas that at the output of FF2 uses only the positive pulses. All these pulses are combined in an integrator, resulting in a stable control voltage. Since both the Q and the $\overline{Q}$ output are used, the ripple is halved.

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The clock is constructed around a CD4060 and an inexpensive watch crystal. The crystal may, of course, be replaced by a different type, as long as this has the required stability.

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The circuit is powered by a 12-V supply that is brought down to 5 V and stabilized by regulator IC5.

Indicator D6 remains out as long as long as the oscillator frequency is stable. If the frequency drifts, the lED lights, its colour and intensity indicate in what direction drift occurs and how serious the drift is.

The integrating action may be disabled by S1, which allows the circuit to settle down more rapidly than with it on. ■

COMPONENTS LIST

Resistors:

3	1k	R1;R11;R13
1	10k	R2
1	2k2	R3
6	1M0	R4–R7;R10;R12
1	10M	R8
1	220k	R9
2	680Ω	R14;R15

Capacitors:

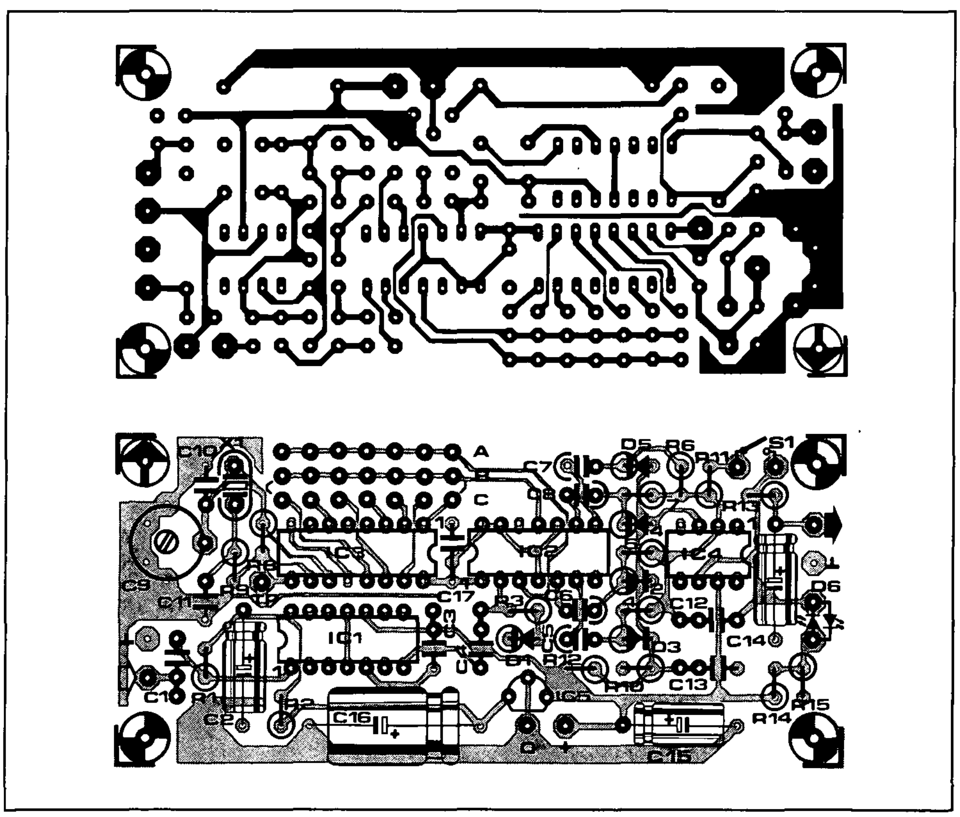
1	22n ceramic	C1
1	4µ7 16V	C2
1	100nF ceramic	C3
1	10nF ceramic	C4
4	470pF polystyrene	C5–C8
1	60pF trimmer	C9
1	33pF	C10
1	68pF	C11
2	1µ0 MKT	C12;C13
2	47µF 16V	C14;C15
1	100nF MKT	C17

Semiconductors:

5	1N4148	D1–D5
1	bicolour LED	D6
1	uA733	IC1
1	74F74 or 74S74 or 74AS74	IC2
1	CD4060	IC3
1	LF411	IC4
1	78L05	IC5

Miscellaneous:

1	SPST switch	S1
1	crystal 32.768 kHz	X1
1	PCB	894023



INTERVAL CONTROL FOR CAMCORDERS

Philip Bosma

Prices of camcorders have shown a welcome reduction over the last year or so, and an increasing number of enthusiasts are using these successors to the 8-mm and 16-mm film camera. The circuit described here is an accessory that allows recordings to made of events that take a relatively long time. The opening of a flower, for instance, can be filmed at regular intervals and then played back in a few seconds.

The recording principle of the camcorder is basically the same as that of a film camera: a series of individual pictures is captured and subsequently played back to reproduce the original visual impressions. The camera of a camcorder has a range of shutter speeds, in economy models ranging from $1/50$ to $1/1000$ and in the more luxury models from $1/50$ to $1/4000$. Short shutter times allow the user to make recordings of relatively fast events as they occur in, for instance, sports. By contrast, long shutter times are required to ensure sufficient intensity of incident light on the recording element, which is usually a CCD (charge-coupled device). As in film cameras, these shutter speeds are not suitable for slow-motion filming, which therefore requires a different approach.

The usual method is to make short recordings at regular, adjustable, intervals. When these recordings are played back at the normal speed, the relatively slow event is reproduced at a much faster rate. In this manner, a slow event with gradual change that takes, for instance, an hour, may be shown in a few minutes or even a few seconds.

The circuit described here is switched on automatically during a predefined period of time. After each recording period, the camcorder is switched back to the stand-by state, the length of which is also defined by the user. The circuit effectively disables the interval switch (or pause switch) in the camcorder. This switch is usually of little use and offers a fairly crude control.

Practical use of the control is simple: fit the camera on a tripod or mount it on a table, aim and focus it on the flower, and switch on the interval control. After half an hour, or an hour, or even longer, depending on the flower, a perfect recording has been made of the flower opening.

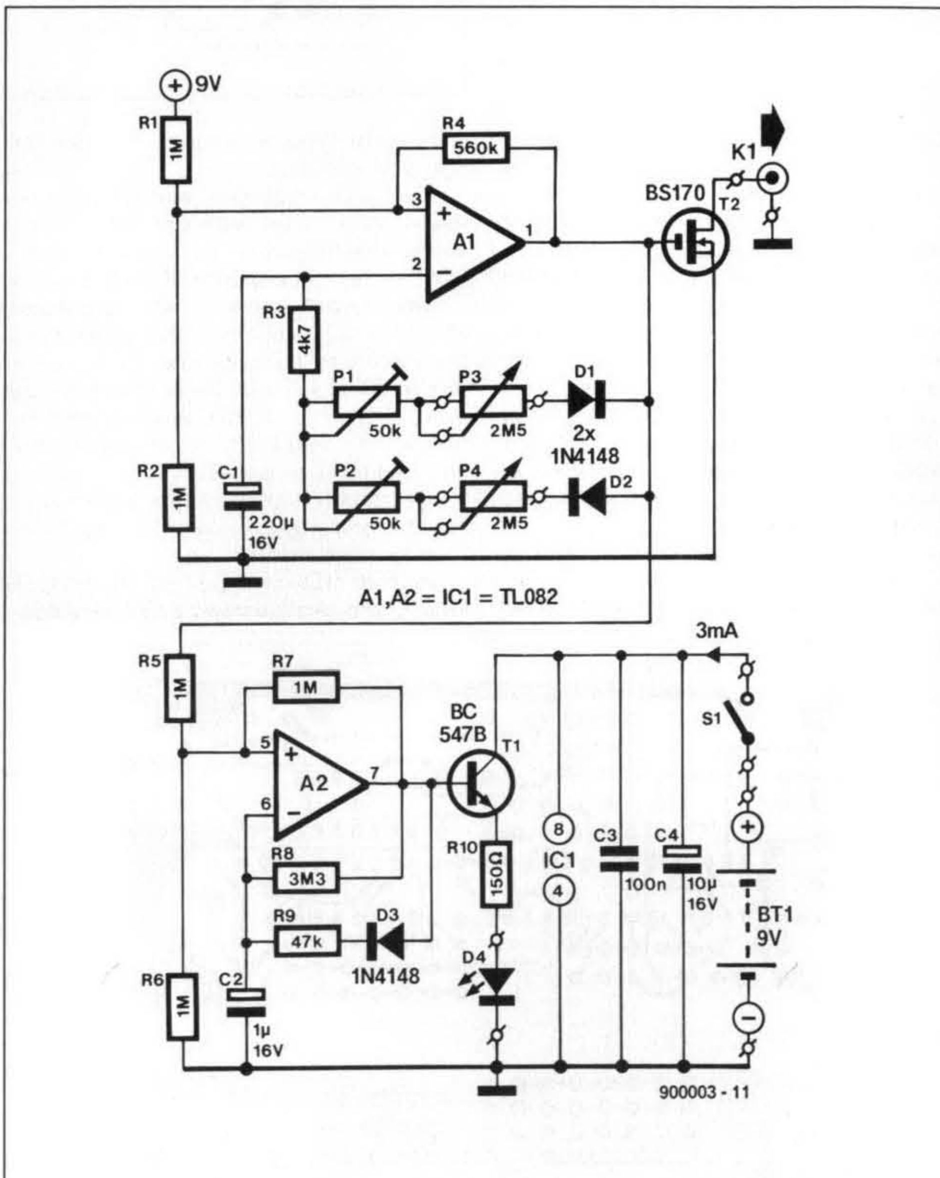


Fig. 1. Circuit diagram of the interval control, which is basically an astable multivibrator with adjustable on and off times.

The circuit

The circuit diagram shown in Fig. 1 could hardly be simpler. Note that only one IC is used, and that about half the circuit serves no other purpose than the control of an indicator LED. The result is a small circuit board for which a compact enclosure should be easy to find. A single 9-V PP3-size battery is used to power the interval switch. Since the circuit consumes little power, the battery should offer sufficient capacity for extended periods of operation.

The interval control is basically an astable multivibrator with adjustable frequency and duty ratio. Resistors R_1, R_2 and R_4 determine the voltage at the non-inverting input of opamp A_1. Because of feedback resistor R_4, the voltage at the non-inverting opamp input is either ¼ or ¾ of the supply voltage, depending on the output voltage of the opamp. The hysteresis so created in the switching behaviour of the opamp causes it to function as a kind of Schmitt-trigger. The *R-C* combination between the inverting input and the output of the opamp extends this function to that of a multivibrator.

The opamp output is high if the voltage across C_1 is lower than $0.25U_b$. The time needed to charge C_1 from the low trigger threshold, $0.25U_b$, to the high trigger threshold, $0.75U_b$, is determined by preset P_2 and potentiometer P_4. The total resistance set with P_2 and P_4 is in direct proportion to the time the opamp output remains high. When the voltage across C_1 exceeds the high threshold level, the opamp output goes low. As a result, C_1 discharges until the lower trigger threshold is reached. Diodes D_1 and D_2 allow different times to be set for the charging and discharging of C_1.

Transistor T_2 conducts as long as the opamp output is high. In this condition, the remote control inputs of the camcorder are connected via MOSFET T_2 so that the recording function is switched on. This lasts until C_1 has discharged to the lower threshold level, when the opamp toggles and T_2 is switched off.

The component values in the mutivibrator allow maximum recording-on and recording-off times of about 400 s to be set. A minimum setting is provided by preset P_1 to ensure that the camcorder has sufficient time to produce a synchronized picture. This minimum recording interval is called the backspace time and is specified in the user manual with most camcorders. If the backspace time is not known, it is fairly simple to establish from a few experiments.

The second part of the circuit is the recording-on indicator set up around opamp A_2. This is configured as an astable multivibrator of which the duty factor and output frequency are fixed. It is started the moment A_1 supplies a high level. Diode D_3 causes the on-time of A_2 to be much shorter than the off-time so that LED D_3 flashes. This is done to reduce the average current consumption of the circuit to about 3 mA whilst ensuring a clear indication that a recording is being made.

Building the control

Figure 2 shows the component mounting plan and the mirror image of the track side of the small PCB. Construction of the circuit is straightforward. Start by fitting the solder pins, followed by the resistors, presets and capacitors. Next, mount the diodes, the integrated circuit and the transistors. Use little solder and work accurately.

Potentiometers P_2 and P_4 are either soldered direct to the board, or connected to it via short lengths of insulated wire.

Finally, fit the circuit into a small ABS

enclosure with a battery compartment. The timing controls, the on/off switch and the indicator LED should be fitted on the top panel for easy access.

The interval control is connected to the camcorder by a short length of 2-wire cable. A 3.5 mm jack plug is used at the side of the interval control, and a 3- or 5-pin DIN plug at the side of the camcorder. ■

COMPONENTS LIST

Resistors:		
5	1M0	R_1;R_2;R_5;R_6;R_7
1	4k7	R_3
1	560k	R4
1	3M3	R_8
1	47k	R_9
1	150Ω	R_{10}
2	50k preset H	P_1;P_2
2	2M5 lin. potentiometer	P_3;P_4
Capacitors:		
1	220µ 16V	C_1
1	1µ0 16V	C_2
1	100n	C3
1	10µ 16 V	C_4
Semiconductors:		
3	1N4148	D_1;D_2;D_3
1	LED	D_4
1	BC547B	T_1
1	BS170	T_2
1	TL082	IC_1
Miscellaneous:		
1	3.5 mm jack socket	K_1
1	miniature SPST switch	S_1
1	PCB	900003

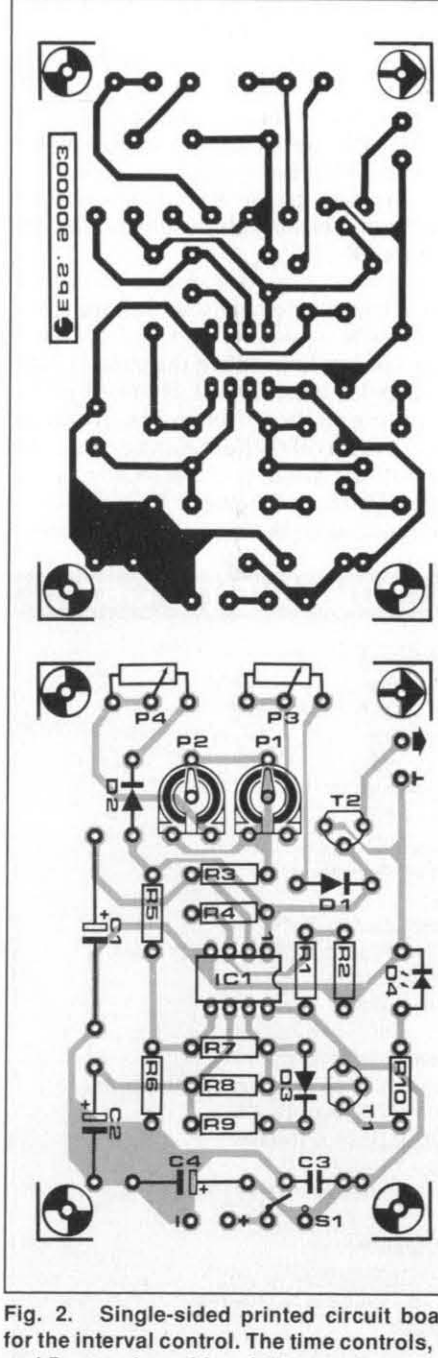
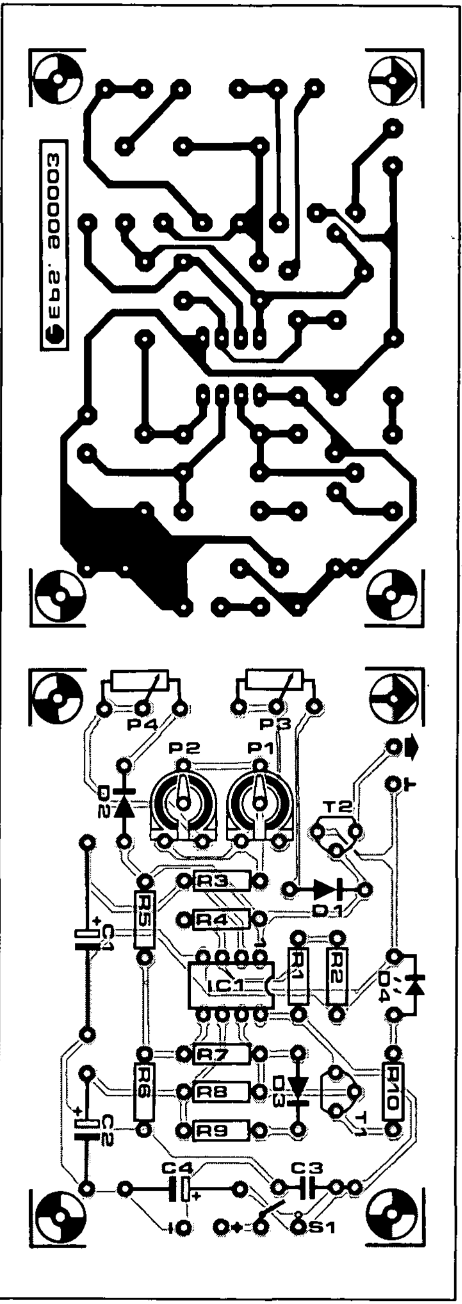
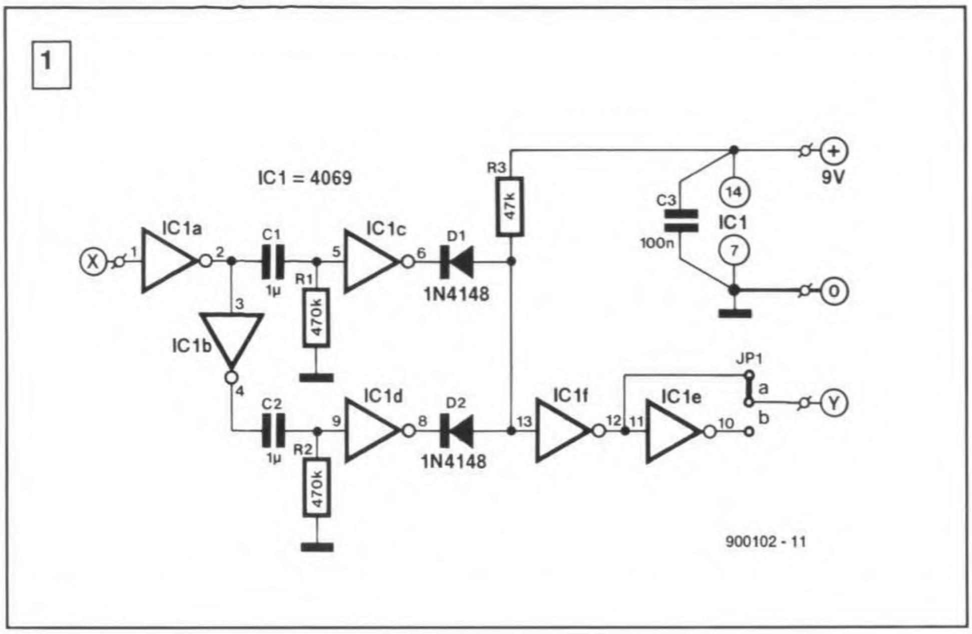


Fig. 2. Single-sided printed circuit board for the interval control. The time controls, P_3 and P_4, may be soldered direct to the board.


P4
P3
P2
P1
D2
T2
R3
D1
R5
C1
R4
IC1
R1
R2
D4
R7
R6
R8
D3
R10
T1
C2
R9
C4
C3
S1

INTERVAL CONTROL FOR CAMCORDERS — AN UPDATE

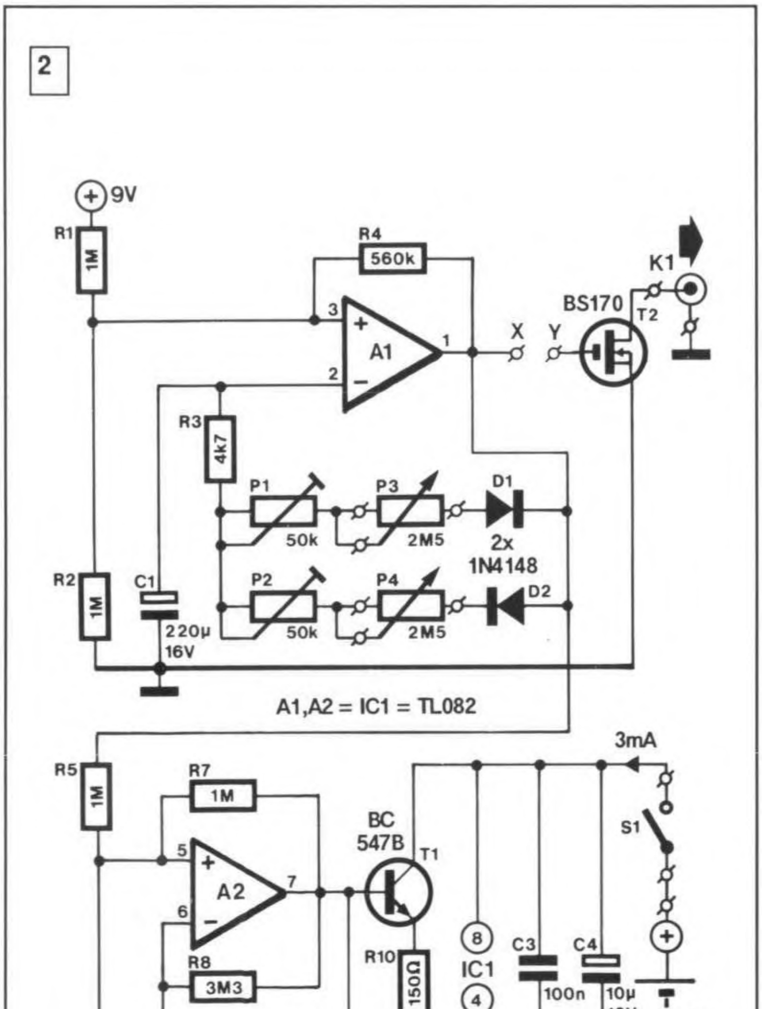


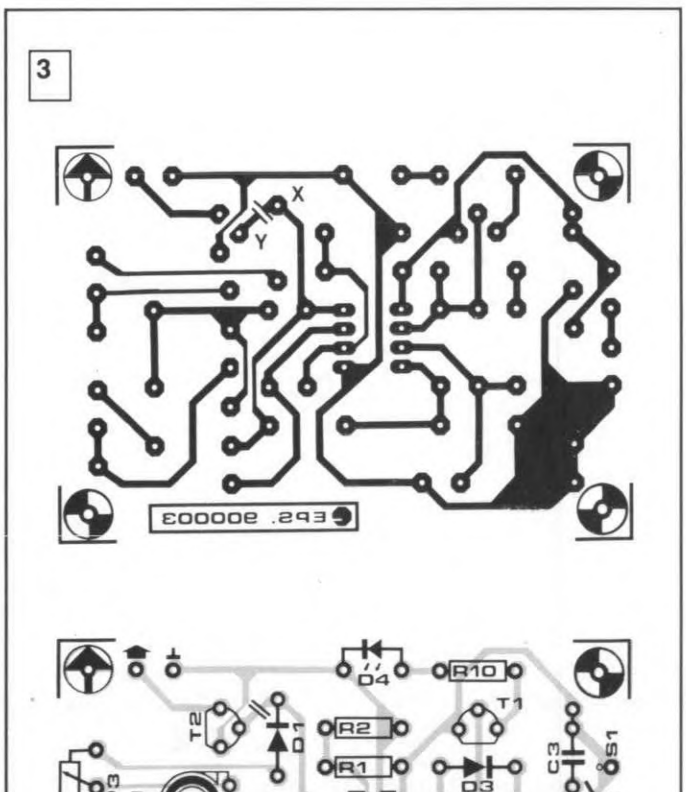
THE original design of an interval control for camcorders (Ref. 1) works with camcorders that are switched on when the RECORD switch is pressed, and off when the switch is released. However, there are also types with a toggle function of the RECORD switch. These are switched on when the RECORD switch is pressed, and off when the same switch is pressed again.

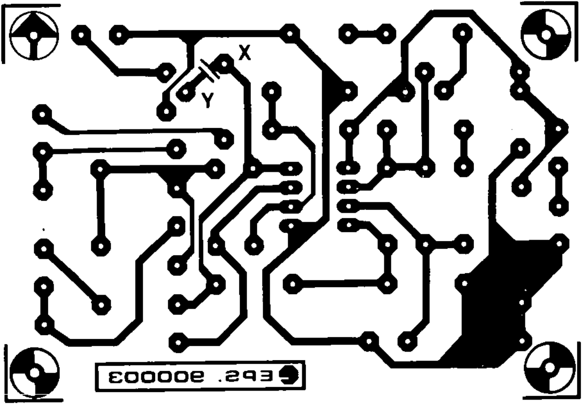
To allow the control to be used with the latter type of camcorder, the original circuit must be fitted with the extension shown in Fig. 1. The extension is inserted between terminals X and Y as indicated in Fig. 2. The track layout and component mounting plan in Fig. 3 show where to create terminals X and Y on the PCB.

With some camcorders, the proposed extension has one disadvantage: after switching on the camcorder, you are not sure whether it records or not when LED D4 flashes. If this problem occurs, make a habit of pressing the RECORD switch once, to make sure that the LED flashes when the camcorder is recording. ■

Reference:
"Interval control for camcorders", *Elektor Electronics* March 1990.






X
Y
EPS 900003

REPLACEMENT FOR TCA280A

The "Computer-controlled slide fader" we published in 1988 (Ref. 1) was based on dimmer chip Type TCA280A. In spite of this device being a Philips Components preferred product at the time, it proved difficult to obtain for many readers. When approached, Philips Components admitted that they had taken the TCA280A out of production without prior warning, and that no pin-compatible replacement was available.

It has taken us some time to find a suitable replacement and have found that the Type TCA785 from Siemens is a good, but not pin-compatible, substitute, which also required some redesigning of the original circuit. The result is shown in the circuit diagram, Fig. 1.

The VSYNC input is provided with a 50 Hz square wave, which is used internally for mains synchronization. The IC is powered via R_2, D_3, C_1 and zener diode D_4.

An internal current source, set by P_1 and R_5, causes a linearly rising voltage on C_3. At each zero crossing of the mains voltage, C_3 is discharged rapidly, so that the potential across it has a sawtooth waveform. The amplitude depends on the setting of P_1.

The sawtooth voltage is compared with a control voltage that is applied to pin 11 of IC_1 via filter R_3-C_2. If the sawtooth voltage rises above the control voltage, a pulse is generated at pin 14 or 15, depending on the current half cycle (positive or negative) of the mains voltage. The two outputs are connected to a triac via diodes D_5-D_6 and resistor R_6, which enable the triac to be triggered. The instant that the triac begins to conduct is, therefore, dependent on the control voltage at pin 11, resulting in a voltage-controlled dimmer. The control voltage may be provided by the slide projector or a potentiometer. In the latter case only, it is also possible to dim 12-V halogen lamps. Zener diode D_4 then needs to be replaced by an 8.2 V type.

The dimmer is aligned by adjusting P_1 in the off condition, when the control voltage is at a maximum, until the lamp just glows.

The slide projector is aligned by setting the relevant potentiometer on the projector PCB to the centre of its travel, when the lamp(s) should be out.

When that is done, the lamp(s) should be switched on and off a couple of times to make sure that the two potentiometers (P_1 and that on the projector board) are adjusted correctly.

Since the control characteristic of the TCA785 is different from that of the TCA280A, it is not advisable to mix the two devices.

When S_1 in the present dimmer is closed, the projector lamps are off: in other words, for normal operation, S_1 must remain open and it may, therefore, be omitted in some cases. ■

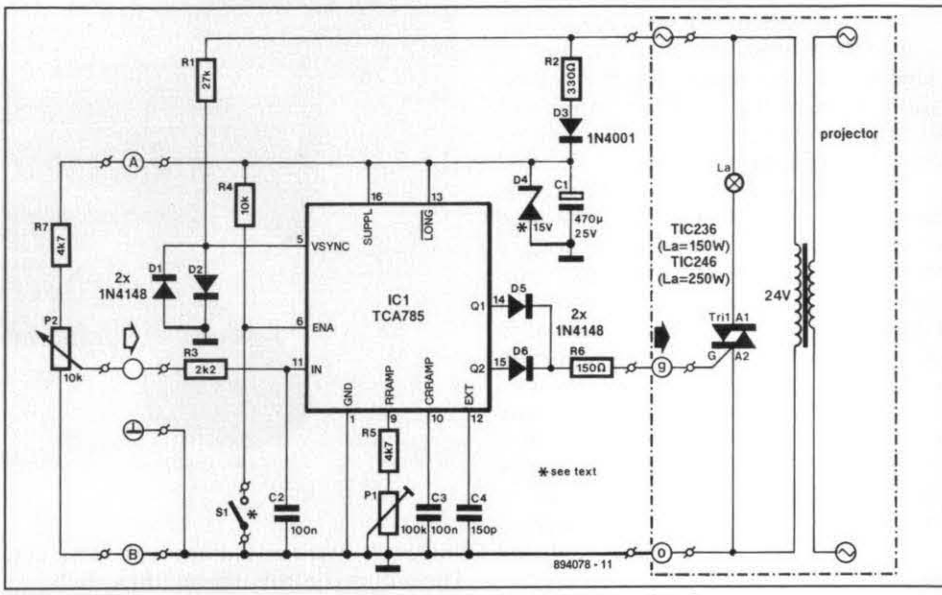


Fig. 1. Circuit diagram of the TCA785-based lamp dimmer circuit.

COMPONENTS LIST

Resistors:
R_1 = 27k
R_2 = 330Ω
R_3 = 2k2
R_4 = 10k
R_5;R_7 = 4k7
R_6 = 150Ω
P_1 = 100k preset H
P_2 = 10k linear potentiometer

Capacitors:
C_1 = 470µ; 25 V (fitted at track side)
C_2;C_3 = 100n
C_4 = 150p

Semiconductors:
IC_1 = TCA785 (Siemens; ElectroValue Ltd.)
Tri_1 = TIC236 or TIC246
D_1;D_2;D_5;D_6 = 1N4148
D_3 = 1N4001
D_4 = zener diode 15 V; 1 W

Miscellaneous:
S_1 = miniature SPST switch.
PCB Type 894078 (see Readers Services page).

Reference:

1. "Computer-controlled slide fader" *Elektor Electronics* March 1988 and April 1988.

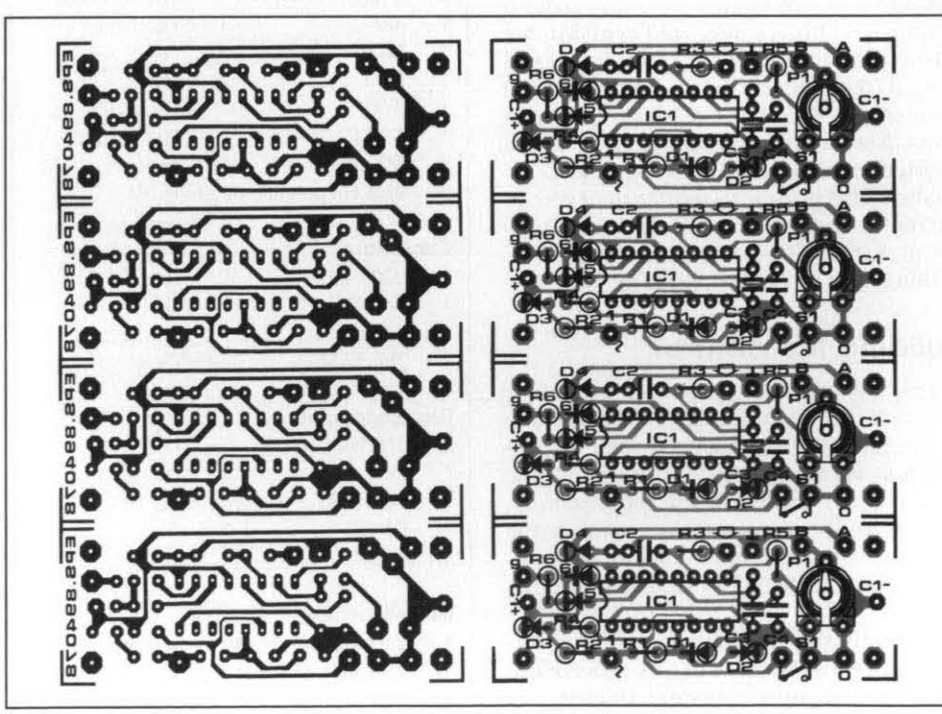


Fig. 2. The printed-circuit board may be used for four lamp dimmer circuits.

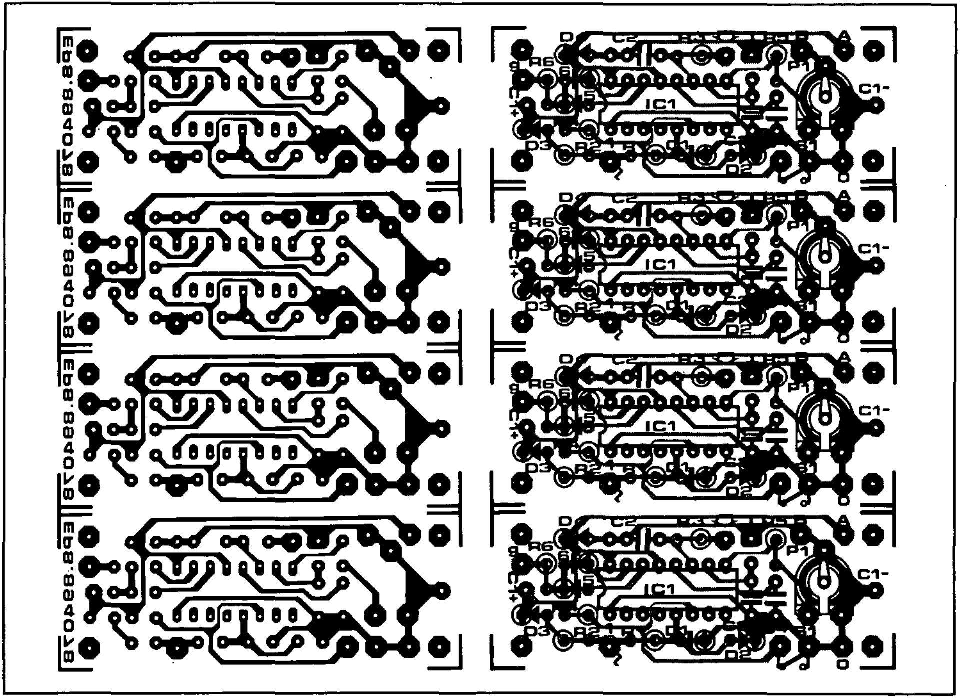
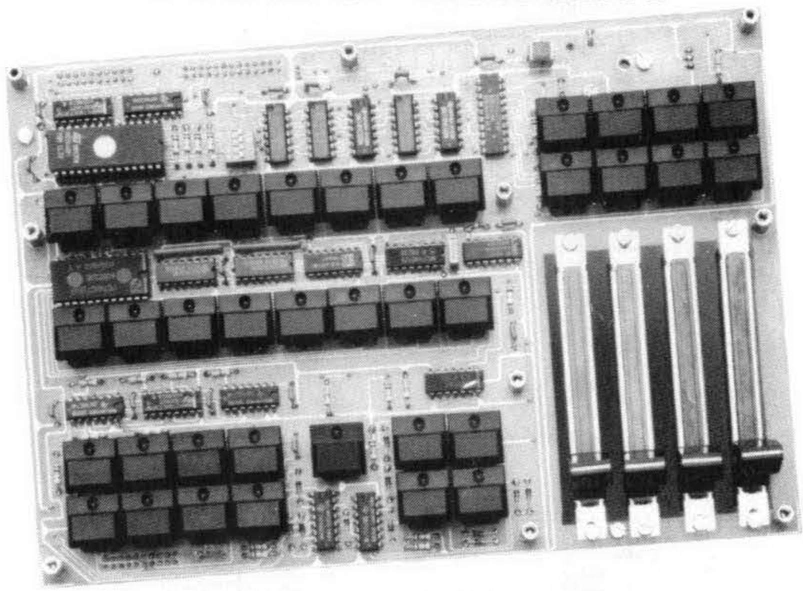


Fig. 2. The printed-circuit board may be used for four lamp dimmer circuits.

VIDEO MIXER



PART 3: KEYBOARD

A. Rigby & G. Dam

This penultimate instalment discusses the third module in the video mixer: the keyboard with its many switches and controls for picture mixing and special wipe effects.

The keyboard circuit forms the user interface of the video mixer. The block diagram in Fig. 11 shows the general structure. Each of the switches shown in a horizontal row roughly at the centre of the diagram has its own LED indicator. The switch states are demultiplexed to give two or, in some cases, four independent control signals. The diagram also shows that the output signals of switches S5–S12 and S30–S35 are synchronized to the VSYNC signal. This means that any action on the keyboard does not take effect until the VSYNC pulse is generated in the mixer. The synchronization eliminates unexpected switching effects occurring at random instants during the current raster.

The lower part of the block diagram contains an EPROM plus associated logic control circuits. The loading of state levels supplied by switches S1–S4 and S14–S29 is synchronized by VSYNC to ensure that the effect associated with a particular switch becomes visible at the start of a new raster only.

After buffering, EPROM datalines D0–D5 are used direct in the mixer. Datalines D6 and D7, however, are first applied to a 1-of-4 decoder to give the required control signals SC15–SC18. The combination of control lines MC1–MC6 and buffered datalines D0–D5 provides a total of 64 different combinations, or 256 combinations if SC15–SC18 are added. Each combination represents a particular picture wipe or mixing effect.

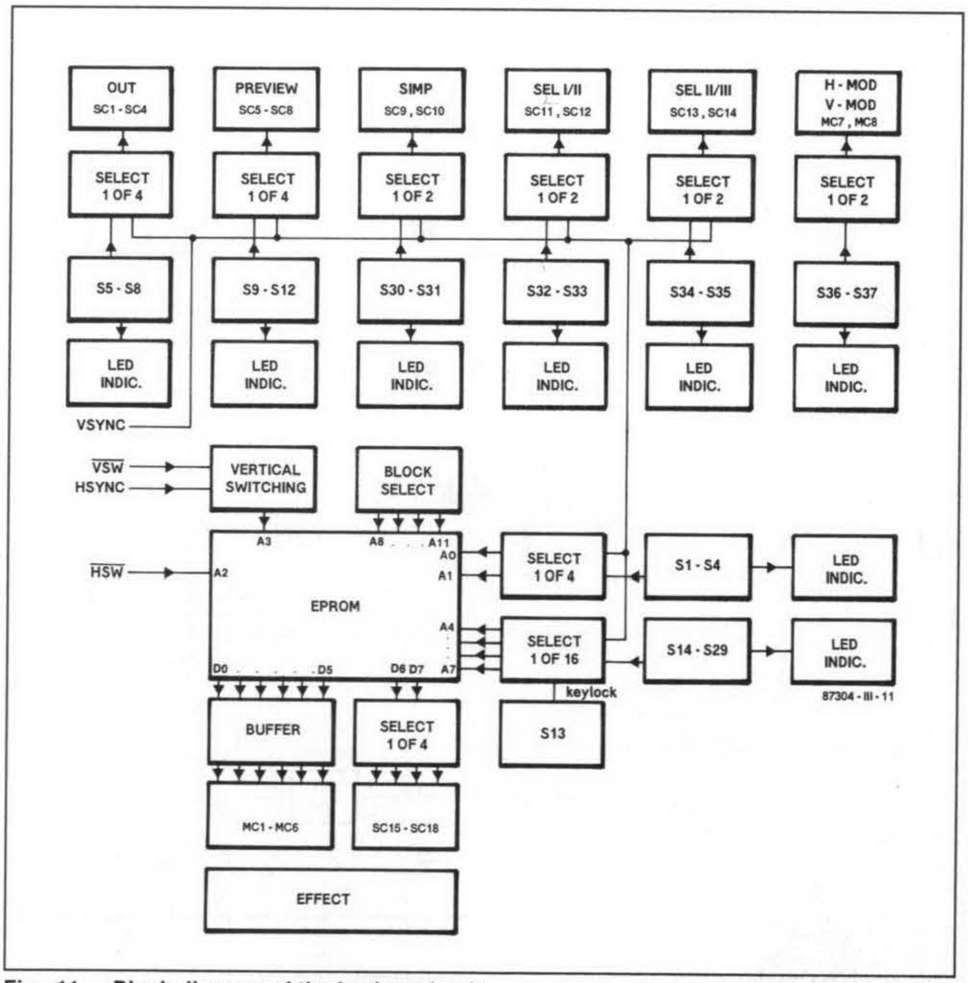


Fig. 11. Block diagram of the keyboard unit.

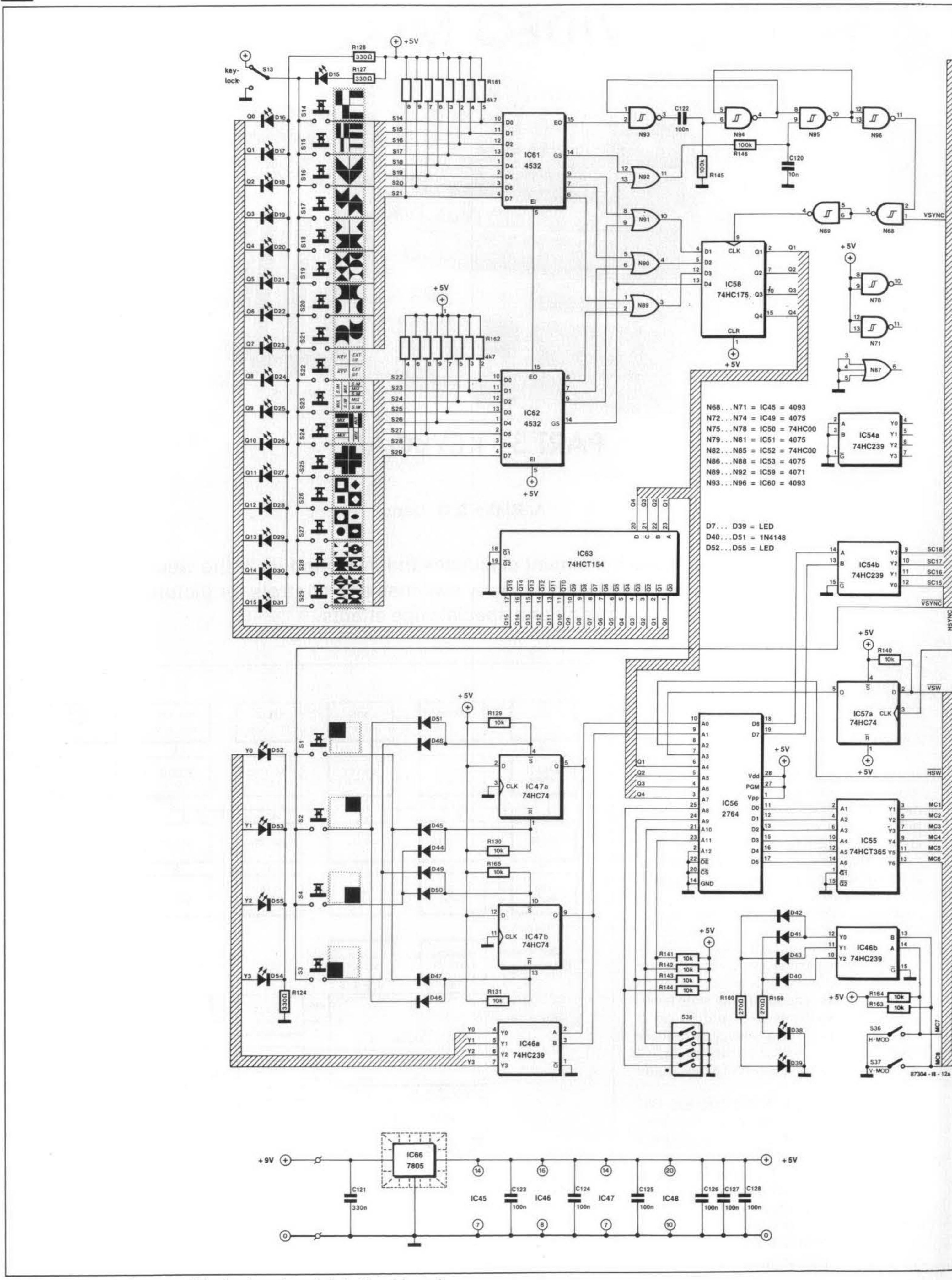
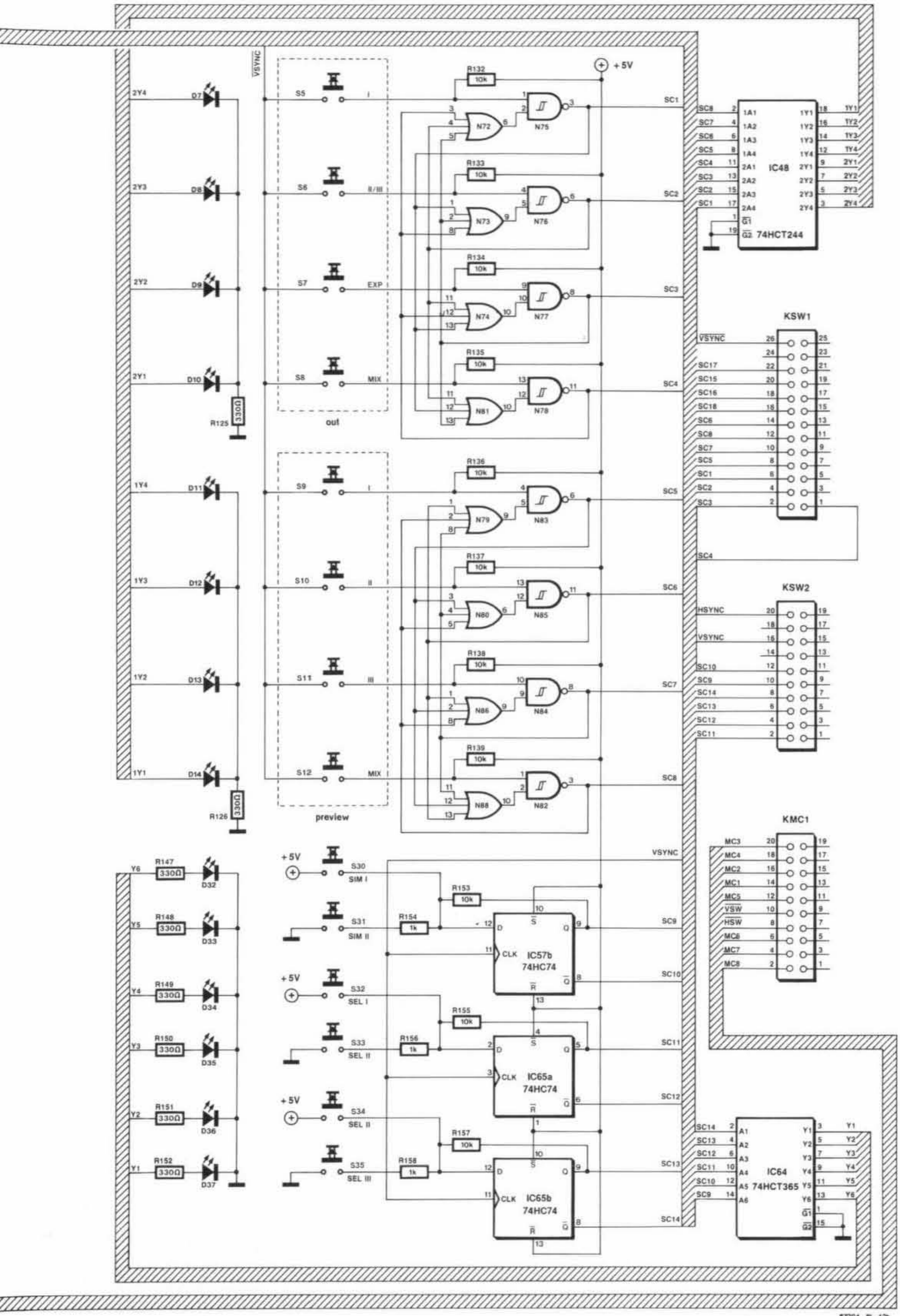
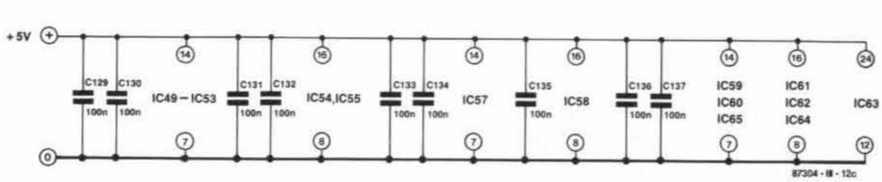


Fig. 12. Circuit diagram of the keyboard module in the video mixer.


+5V
VSYNC
S5
S6
S7
S8
S9
S10
S11
S12
out
preview
I
II/III
EXP
MIX
II
III
D7
D8
D9
D10
D11
D12
D13
D14
R125
R126
330Ω
R132
R133
R134
R135
R136
R137
R138
R139
10k
N72
N73
N74
N75
N76
N77
N78
N79
N80
N81
N82
N83
N84
N85
N86
N88
SC1
SC2
SC3
SC4
SC5
SC6
SC7
SC8
SC9
SC10
SC11
SC12
SC13
SC14
IC48
74HCT244
KSW1
KSW2
KMC1
HSYNC
VSW
HSW
S30
SIM I
S31
SIM II
S32
SEL I
S33
SEL II
S34
S35
SEL III
R147
R148
R149
R150
R151
R152
D32
D33
D34
D35
D36
D37
R153
R154
R155
R156
R157
R158
1k
IC57b
74HC74
IC65a
IC65b
IC64
74HCT365
87304 - III - 12b


+5V
C129
C130
C131
C132
C133
C134
C135
C136
C137
100n
IC49 – IC53
IC54, IC55
IC57
IC58
IC59
IC60
IC65
IC61
IC62
IC64
IC63
0
87304 - III - 12c

Clearly, a total of 256 possible combinations results in an unwieldy number of effects. Therefore, a selection has been made on the basis of practical use. Obviously, this selection is subjective, but the user of the mixer is free to design and store his own set of effects, as discussed later.

In the basic version of the mixer, the EPROM contains only one of 16 possible banks of picture effects —up to 15 may be added as required. The effects obtained from the above selection are stored in the first bank of the EPROM, and may be called up by a total of 20 keys. The first keyboard area consists of 16 keys, S_{14}–S_{29}; while the second area consists of four keys, S_1–S_4. The latter allows the user to select one of four effects offered by one key from the first (20-key) area. If you find this difficult to follow, look at the front-panel lay-out (Fig. 14) which provides all the necessary information for effective control of the mixer.

As already stated, only a small part of the EPROM capacity is used, which leaves the user plenty of room to store new effects combinations. The possibilities and rules that apply to customizing the effects set are detailed further on in this article. The banks with custom-designed effects are accessed with the aid of the block select circuit.

Signals $\overline{VSW}$ and $\overline{HSW}$ are taken from the modulation board to ensure that all switching of video signals arranged by the EPROM runs synchronously with the vertical as well as the horizontal sync pulses.

Practical circuit

The circuit diagram of the keyboard circuit is given in Fig. 12. Although a sizeable circuit, it is the simplest in the video mixer.

Push-buttons S_5–S_8, like S_9–S_{12}, form a group of four switches of which only one is selected at a time. This selection is arranged by a combination of a NAND gate and a 3-input OR gate. Each switch has an associated activity LED which is driven by an output of buffer IC_{48}. The 8 switching signals supplied by S_5–S_{12} leave the PCB via connector KSW_1.

Switches S_1–S_4 provide the two address signals A0 and A1 which select EPROM-resident effects and patterns. Switches S_{30}–S_{35} are alternately connected to ground or the positive supply rail. Actuation of one of these switches is recorded by the bistable that follows it. The bistables are configured as set-reset (S/R) types whose output signals are fed direct to other parts of the circuit as well as to buffer IC_{64} which drives five switch-status LEDs.

The two ICs in the top left-hand corner of the circuit, IC_{61} and IC_{62}, form a priority encoder for switches S_{14}–S_{29}. If one of the eight encoder inputs is made high, the output supplies the binary value of the number of the relevant input. If two keys are pressed simultaneously, the highest value is passed to the output. Since two independent decoders are used, IC_{61} and

		S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4
S14:	XX00-XX0F	75	75	35	35	35	75	35	75	75	35	75	35	35	35	75	75
S15:	XX10-XX1F	77	7D	3D	37	37	7D	3D	77	77	3D	7D	37	37	3D	7D	77
S16:	XX20-XX2F	65	05	45	25	25	45	05	65	65	05	45	25	25	45	05	65
S17:	XX30-XX3F	67	07	47	27	27	47	07	67	67	07	47	27	27	47	07	67
S18:	XX40-XX4F	6D	0D	4D	2D	2D	4D	0D	6D	6D	0D	4D	2D	2D	4D	0D	6D
S19:	XX50-XX5F	6F	6A	2A	2F	2F	2A	6A	6F	6F	6A	2A	2F	2F	2A	6A	6F
S20:	XX60-XX6F	09	69	29	49	49	29	69	09	09	69	29	49	49	29	69	09
S21:	XX70-XX7F	66	06	46	26	26	46	06	66	66	06	46	26	26	46	06	66
S22:	XX80-XX8F	50	40	00	10	10	00	40	50	50	00	40	10	10	40	00	50
S23:	XX90-XX9F	B5	BD	F5	F5	F5	BD	F5	B5	B5	FD	B5	F5	F5	FD	B5	B5
S24:	XXA0-XXAF	BD	B7	B7	BD	BD	37	77	BD	3D	B7	B7	7D	3D	37	77	7D
S25:	XXB0-XXBF	35	35	75	35	35	35	35	75	35	75	35	35	75	35	35	35
S26:	XXC0-XXCF	7F	0F	4F	3F	3F	4F	0F	7F	3F	0F	4F	7F	3F	4F	0F	7F
S27:	XXD0-XXDF	0A	6E	2E	4A	4A	2E	6E	0A	0A	6E	2E	4A	4A	2E	6E	0A
S28:	XXE0-XXEF	6F	6F	2F	2F	6F	2F	6F	2F	6F	6E	2E	2F	2F	2E	6E	6F
S29:	XXF0-XXFF	0E	6E	2E	4E	4E	2E	6E	0E	0F	6F	2F	4F	4F	2F	6F	0F

Table 1. Content of the EPROM type 2764 in the keyboard circuit. Analyze the function of each databyte to learn how to program your own set of picture mixing and wipe effects. Use the data in Table 2 (below) for reference.

		Mixed inputs bits: D7-D6				Reference bits: D5-D4					V-waveform bits: D3-D2				H-waveform bits: D1-D0			
	High nibble	input I	input II/III	mixed	superimpose	invert	normal	slide pot	vertical	Low nibble	key	ramp	parabola	triangle	key	ramp	parabola	triangle
Bin.	D7–D4	00	01	10	11	D5	D5	D4	D4	D3–D0	00	01	10	11	00	01	10	11
00 00	0	x				x			x	0	x				x			
00 01	1	x				(x)		x		1	x					x		
00 10	2	x					x		x	2	x						x	
00 11	3	x					(x)	x		3	x							x
01 00	4		x			x			x	4		x			x			
01 01	5		x			(x)		x		5		x				x		
01 10	6		x				x		x	6		x					x	
01 11	7		x				(x)	x		7		x						x
10 00	8			x		x			x	8			x		x			
10 01	9			x		(x)		x		9			x			x		
10 10	A			x			x		x	A			x				x	
10 11	B			x			(x)	x		B			x					x
11 00	C				x	x			x	C				x	x			
11 01	D				x	(x)		x		D				x		x		
11 10	E				x		x		x	E				x			x	
11 11	F				x		(x)	x		F				x				x

x = function selected.

(x) = function selected but overridden.

Table 2. Correlation between EPROM content and picture mixing effects.

```
S14 0000: 75 75 35 35 35 75 35 75 75 35 75 35 35 35 75 75
          ↓  ↓  ↓  ↓  ↓  ↓  ↓  ↓  ↓  ↓  ↓  ↓  ↓  ↓  ↓  ↓
          S1 S2 S4 S3 S1 S2 S4 S3 S1 S2 S4 S3 S1 S2 S4 S3
          |---------| |---------| |---------| |---------|
           HSW = 0     HSW = 1     HSW = 0     HSW = 1
          |---------------------| |---------------------|
                 VSW = 0                 VSW = 1
                                                   87304-III-T3
```

Table 3. Sixteen bytes are reserved for each switch in keyboard area 1. Use the data in Table 2 to establish the associated mixer functions.

IC_{62} are cascaded via their EI/EO (enable in/out) pins. This ensures that IC_{61} is disabled if one of the keys S_{21}–S_{29} is pressed.

The outputs of the priority encoder are connected to a 4-bit latch, IC_{58}, via three OR gates. The fourth data input of the latch is connected to the GS (group select) output of IC_{62}. As a result, IC_{58} supplies a 4-bit key identification code. Gates N_{93}–N_{96} suppress key bounce pulses and other interference. The 4-bit key code is fed direct to address inputs A4–A7 of the EPROM. Address inputs A8–A11 are given their respective levels by DIL switch block S_{38}. Address line A12 is grounded, so that only the lower 4 Kbyte of the EPROM is used. The EPROM through the Readers Services, all switches in S_{38} must be closed. Alternatively, four wire links may be installed.

EPROM address line A3 is connected to the $\overline{VSW}$ signal. Bistable IC_{57a} ensures that level changes of the $\overline{VSW}$ signal are synchronized to the line-sync signal to prevent video source switching in the current picture line.

Address line A2 is switched by the $\overline{HSW}$ signal, while the levels of A0 and A1 are determined by switches S_1–S_4. The relation between the EPROM address and the effect on the picture is discussed further on.

Construction

The last module of the video mixer desk consist of two printed-circuit boards which are available ready-made as one piece through the Readers Services. The PCB is double-sided and through-plated. First, use a jig-saw to cut out the part which is to hold the mains transformer and the two PCB terminal blocks. The edges of this part of the board are indicated by holes.

Mount the transformer and the terminal blocks on the supply board and put it aside for fitting into the enclosure later.

The hole in the keyboard PCB created by removing the supply board forms a clearance for the slide potentiometers.

Mount the following parts at the EPS side of the board: IDC cable headers KSW_1, KSW_2 and KMC_1, and voltage regulator IC_{66}.

Be sure to observe the opposite orientation of SIL resistor arrays R_{162} and R_{163}.

Switches S_{13}, S_{36} and S_{37} are self-locking types.

In some cases, the size of C_{12} forces this capacitor to be mounted at the EPS side of the board.

Since the LEDs are integral to the switches, these parts are mounted at the same time.

To reduce cost, all ICs, except the EPROM, may be mounted without sockets.

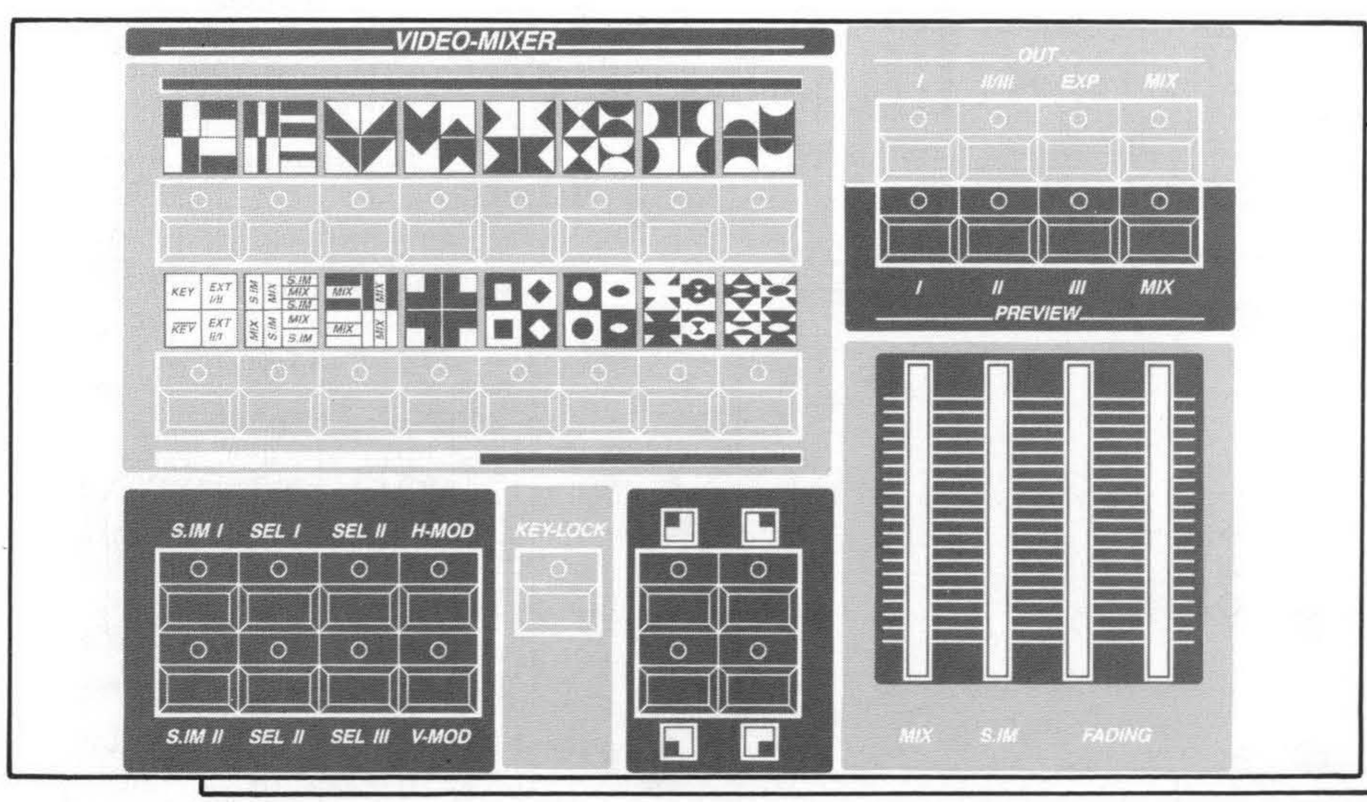


Fig. 13. Front-panel lay-out shown at approximately 30% of true size.

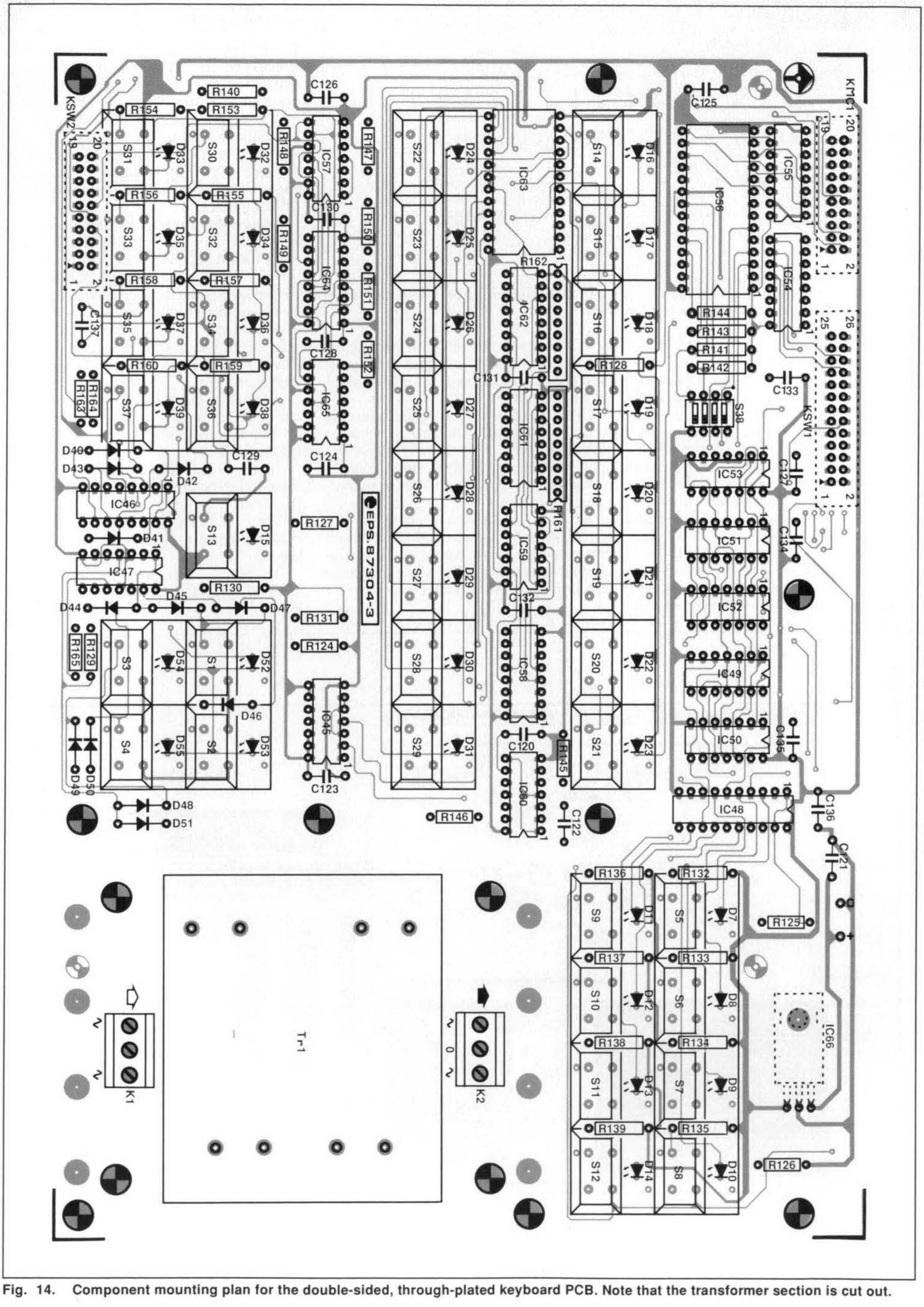


Fig. 14. Component mounting plan for the double-sided, through-plated keyboard PCB. Note that the transformer section is cut out.

COMPONENTS LIST

Resistors:
R124–R128;R147–R152 = 330Ω
R129–R144;R153;R155;R157;R163;R164;
R165 = 10k
R145;R146 = 100k
R154;R156;R158 = 1k0
R159;R160 = 270Ω
R161;R162 = 4k7 (8-way SIL resistor array)

Capacitors:
C122–C137 = 100n
C120 = 10n
C121 = 330n

Semiconductors:
IC45;IC60 = 4093
IC46;IC54 = 74HC239
IC47;IC57;IC65 = 74HC74
IC48 = 74HCT244
IC49;IC51;IC53 = 4075
IC50;IC52 = 74HC00
IC55;IC64 = 74HCT365
IC56 = 2764 (order number 5861; see Readers Services page)
IC58 = 74HC175
IC59 = 4071
IC61;IC62 = 4532
IC63 = 74HCT154
IC66 = 7805
D7–D39;D52–D55 = LED (in switches S1–S37)
D40–D51 = 1N4148

Miscellaneous:
S1–S12;S14–S35 = push-button with integral red LED (Dataswitch 61-10404010*).
S13;S36;S37 = toggle switch with integral red LED (Dataswitch 61-20404010*).
S38 = 4-way DIP switch block.
Tr1 = mains transformer 2×9 V/2×9 VA)
K1;K2 = 3-way PCB terminal block.
KMC1;KSW2 = 20-way PCB header.
KSW1 = 26-way PCB header.
Qty. 2: 26-way IDC plug.
Qty. 4: 20-way IDC socket.
Qty. 1: 25 cm 20-way flatcable
Qty. 1: 40 cm 20-way flatcable
Qty. 1: 60 cm 26-way flatcable
Enclosure: e.g., ESM EP30/20+
PCB Type 87304-3 (see Readers Services page).
Front-panel foil Type 87304-F (see Readers Services page).

* ITW Switches • Division of ITW Limited • Norway Road • Hilsea • PORTSMOUTH PO3 5HT. Telephone: (0705) 694971.

+ ESM • 119 Rue des Fauvelles • 92400 Courbevoie • France. Telephone +33 1 47.68.50.98. Telex: 630612.

The remainder of the construction is straightforward. Work accurately and use little solder to prevent short-circuits. Always remember that fault-finding in a circuit like this can be costly and time-consuming.

Custom effects: over to you

Table 1 shows the structure of the contents of the EPROM Type 2764 for this project. The 8 databits of the EPROM control a number of functions of the mixing desk. The relations between the bits and the functions are summarized in Table 2. The two least-significant bits, D0 and D1, select one of four horizontal effects voltages. Similarly, D2 and D3 select one of four vertical effects voltages. Databits D4 and D5 select the source that determines the horizontal reference voltage for the switching of HSW: this source is either the vertical effects voltage or the horizontal wipe potentiometer. Databit D5 controls the inversion of the picture. The two most-significant databits, D7 and D8, select the input signal source. The table and the bit assignment should enable you to analyse the function of each databyte in the 'standard' EPROM fairly quickly.

The logic levels present at the EPROM address inputs determine which of the databytes is applied to the EPROM datalines. This address emanates from switches S1–S4 and S14–S29, and the HSW and VSW signals. The functions of the entries in Table 2 are explained below. First, however, assume that the remaining address lines are low.

The table contains 16 lines, one for each effect switch in area 1. The remaining address locations in the 'standard' EPROM are empty. Each line invariably contains 16 bytes, each of which can be selected individually by applying the relevant address. Table 3 lists the functions of all variables. If, for instance, switches S1 and S14 are pressed (horizontal wipe), the first byte in the EPROM is initially put on the databus. Write down the binary structure of the byte. From Table 2, it is analyzed as follows:

- Input II/III is used;
- the horizonal reference voltage is supplied by the potentiometer;
- the horizontal effects voltage is a ramp;
- the vertical effects voltage is a ramp.

When HSW is active —as a result of the horizontal ramp exceeding the reference level set with the potentiometer —the fifth byte is applied to the databus. Again referring to Table 2, input 1/2 is selected. This mode causes a horizontal wipe effect with the position of the picture transition being determined by the slide potentiometer for the horizontal effects.

The function of the EPROM-based control words is similar for the vertical effects (assume that S2 and S4 are pressed). Designing and storing one's own picture effects is not simple. The tables and analysis of the 'default' effects in the EPROM, however, should provide sufficient information to get you started.

The last instalment of this article will appear in next month's issue of *Elektor Electronics*. Parts 1 and 2 appeared in the January and February 1989 issue respectively.

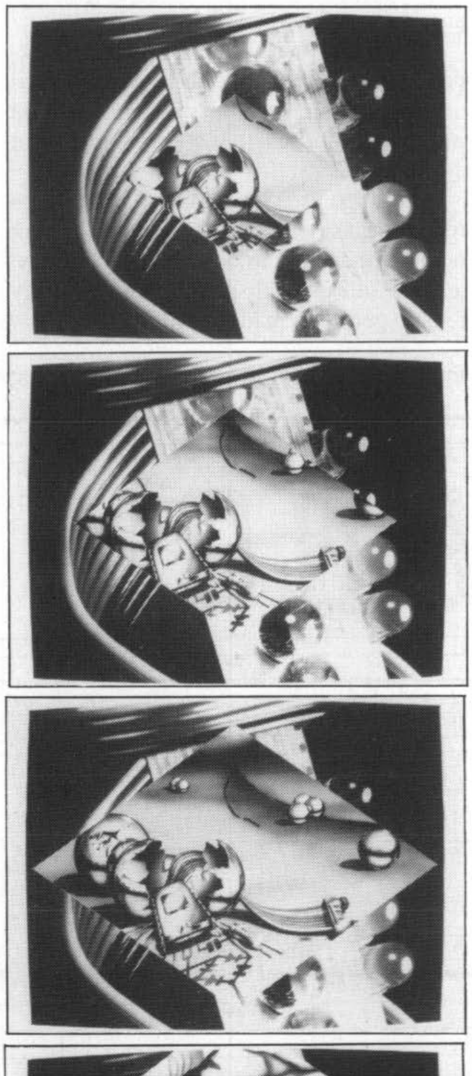


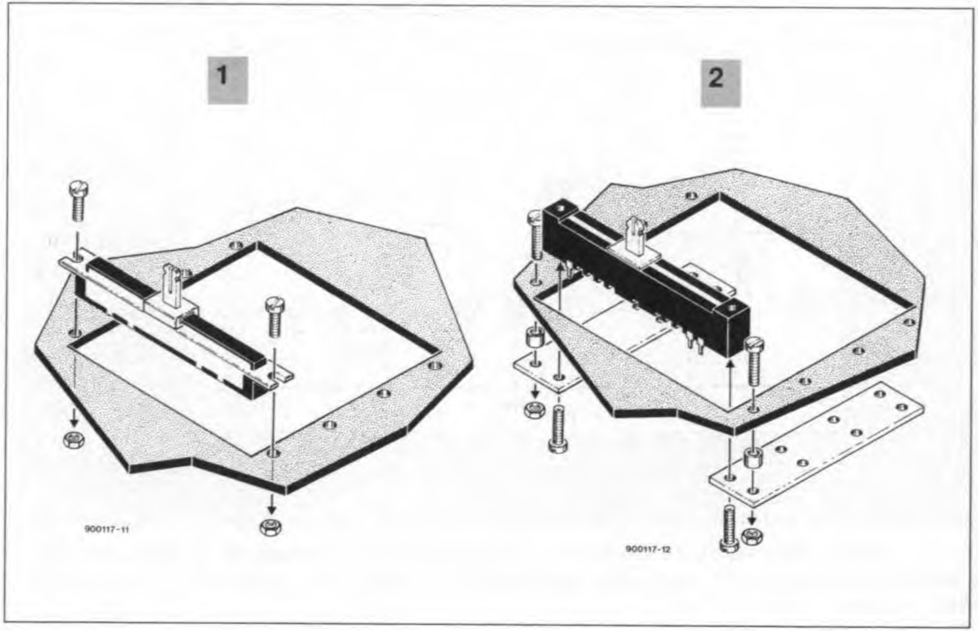
Fig. 15. Example of a picture-mixing effect in four stages.

SLIDE POTENTIOMETERS IN THE VIDEO MIXER — AN UPDATE

We understand that the mounting of the slide potentiometers in the video mixer published last year has caused a small difficulty with some constructors.

There appear to be two types of slide potentiometer around, which, although they have the same track length, are mounted differently. In some cases, the type with two mounting lugs (Fig. 1) requires a few washers, or short PCB spacers, to be positioned at the right height above the PCB. The second type (Fig. 2) has two holes through the potentiometer body. To enable this type to be secured to the PCB, mount two small support plates and two spacers at the track side of the PCB, as shown in Fig. 2. The length of the spacers is determined by the required height of the slide potentiometer above the PCB surface. ■

"Video Mixer", *Elektor Electronics* January, February and March 1990.



DESIGN IDEAS

The contents of this column are based solely on information supplied by the author and do not imply practical experience by *Elektor Electronics*

LOW-COST V/I DISPLAY MODULE

by Mohd Abdul Sami

The circuit described here is a modification to the "Digital V/I Display" published in this magazine some years ago(1). It can display more than one analogue input (on different read-outs), although it uses only one analogue-to-digital converter.

The circuit diagram shows that the multiplexer, IC4, is clocked by the MSD (most significant digit) output of analogue-to-digital converter (ADC) IC1 via switch IC5c. As soon as the MSD output reveals that the relevant input has been converted and channelled to the output, the counter increments and another analogue input is selected by the ADC. The design is such that only one switch and one BCD-to-7-segment decoder (IC2 or IC3) are enabled at any one time.

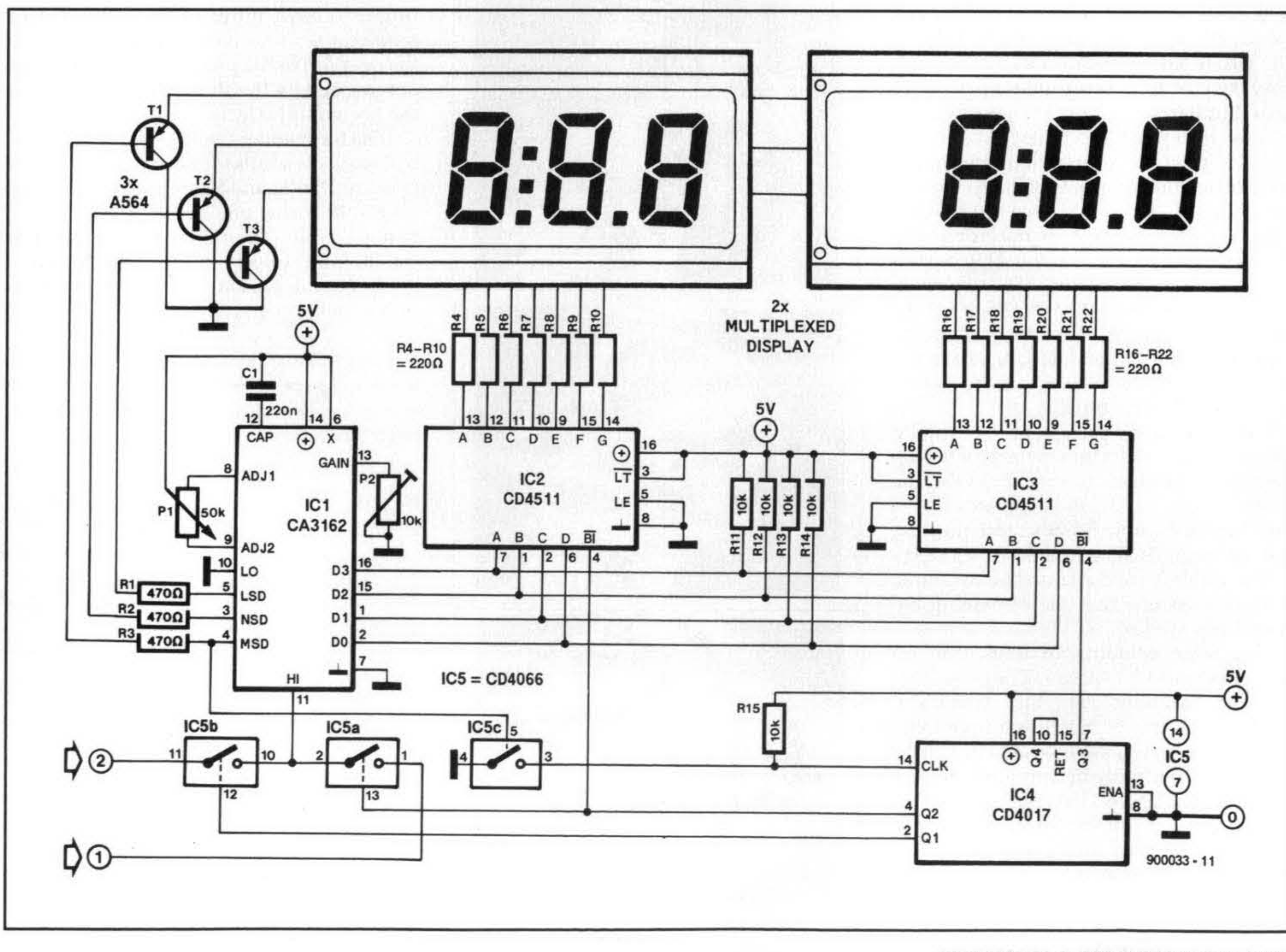
When the counter increments, its output disables the blanking input of the appropriate 7-segment decoder. At the next increment, Q3 resets the counter and the cycle repeats itself.

Although it is possible to have three read-outs, the clock of the CA3162 is not really fast enough to ensure correct persistence of all three displays, although they remain perfectly readable.

If a third read-out is used, Q3 of IC4 must be connected to the control input of an additional switch, Q4 to the blanking input of the decoder, and Q5 to the reset of the counter.

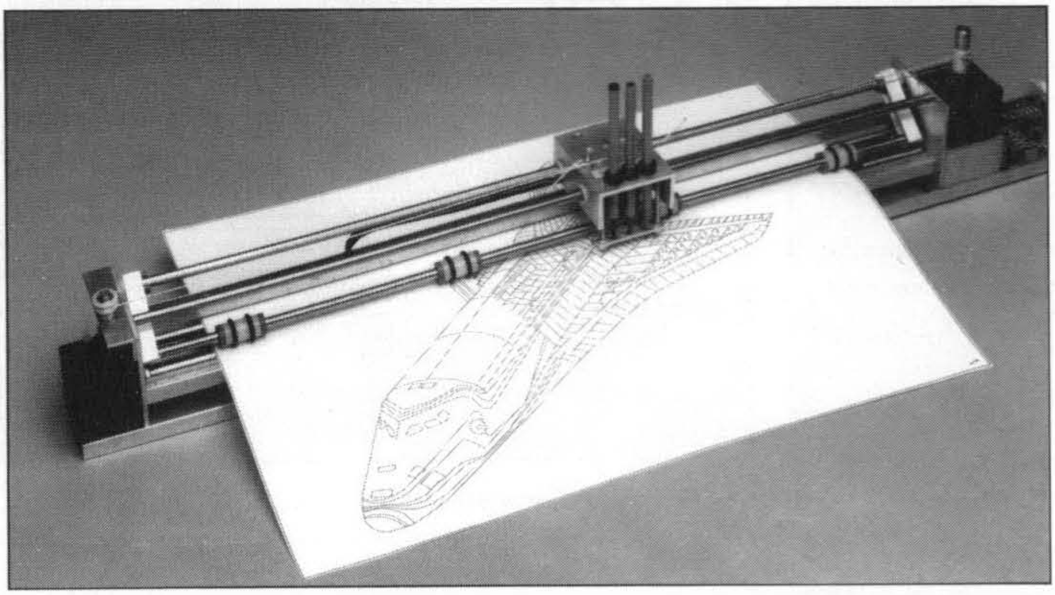
The input voltage range is 0–0.999 V. The reference potential of all inputs is the L0 input of IC1. ■

(1) July/August 1987, Supplement, p.5



PLOTTER MARK-II

with a contribution by B. Lewetz



The plotter we published roughly two years ago is among our most popular projects thanks to a relatively simple mechanical construction and the availability of an associated stepper motor driver board. Although a number of readers have sent us suggestions for software drivers that would enable the plotter to be used with popular computers, only Mr. Lewetz' contribution proved to meet the requirements as regards use of the driver on IBM PCs, and (at least partial) compatibility with the industry-standard HPGL plotter command language. Before introducing the software, however, we avail ourselves of the opportunity to propose some improvements to the mechanical design of the plotter.

Like its predecessor (Ref. 1), the Mark-II version of the plotter uses paper movement for the Y-direction, and pen movement for the X-direction. As such, the operation of the plotter is not unlike that of a matrix printer. The platen which causes the paper movement is operated direct by a stepper motor. The pen carriage is coupled to another stepper motor via a string. Small solenoids control the pen up/down movement. The simple mechanical construction and the possibility of customizing the plotter width in accordance with the maximum required paper width are important factors that made us prefer the above arrangement over the more complex X-Y variant.

The plotter works in conjunction with a control board which translates a bit-pattern applied to its input into the corresponding control signals for the three solenoids and two stepper motors. The circuit is based on two special stepper motor driver ICs from Motorola which obviate complex bit-shift and timing operations for the control of the half-step and full-step modes as well as the forward/reverse movement of the stepper motors at the required accuracy. The chips, Type MC3479, allow the 8-bit wide input of the control board to be driven by a Centronics (printer-) port, which is available on almost any IBM PC-XT, AT or compatible. Connection details are given in Fig. 2.

The control board used for the new version of the plotter is that discussed in Ref. 1: no changes are required, and the circuit works in conjunction with the software package described further on.

Mechanical work

Since the mechanical construction of the plotter is discussed at length in Ref. 1, there is no need to repeat it here. The new working drawings, Figs. 1 and 3, and the associated parts list reflect most of the mechanical changes made to the original design. The most important change is that the Mark-II version is about 10 cm wider, which allows A2 paper to be used sideways and A3 paper lengthwise. Four paper rollers are used instead of two for improved accuracy of the Y-movement. Also, the platen is fitted with a 12 mm diameter bearing at the free side to reduce friction (see Fig. 4: the original had a nylon bushing).

Further improvements to the original design have been suggested by numerous readers. The use of a lathe to reduce the diameter of the platen at the locations of the sandpaper grips, for instance, may be gone round by covering the platen in flexible conduit. The same is suggested for the paper rolls. It should be noted, however, that these modifications may result in different step sizes for the horizontal and vertical movement, which may require software-controlled compensation.

Further suggestions as regards improving the mechanical stability of the plotter entail the use of 4-mm thick aluminium, stainless steel or silver steel. One of our readers in Greece, a lathe operator by profession, has built the plotter from stainless steel, using sintered metal for the

MAIN SPECIFICATIONS

Hardware:
- beam plotter for paper size up to DIN-A2 (594×420 mm)
- repeatability: <0.1 mm
- 3 colours
- simple construction
- control board with centronics input

Software:
- partially HPGL compatible (6 commands supported)
- plot commands sent via Centronics port
- compatible with *Elektor Electronics* plotter driver board
- software spooler
- configuration file
- programmable plot speed
- multitasking Turbo-C control program
- auxiliary programs for:
  - keyboard control
  - plot file formatting
  - full/half-step operation

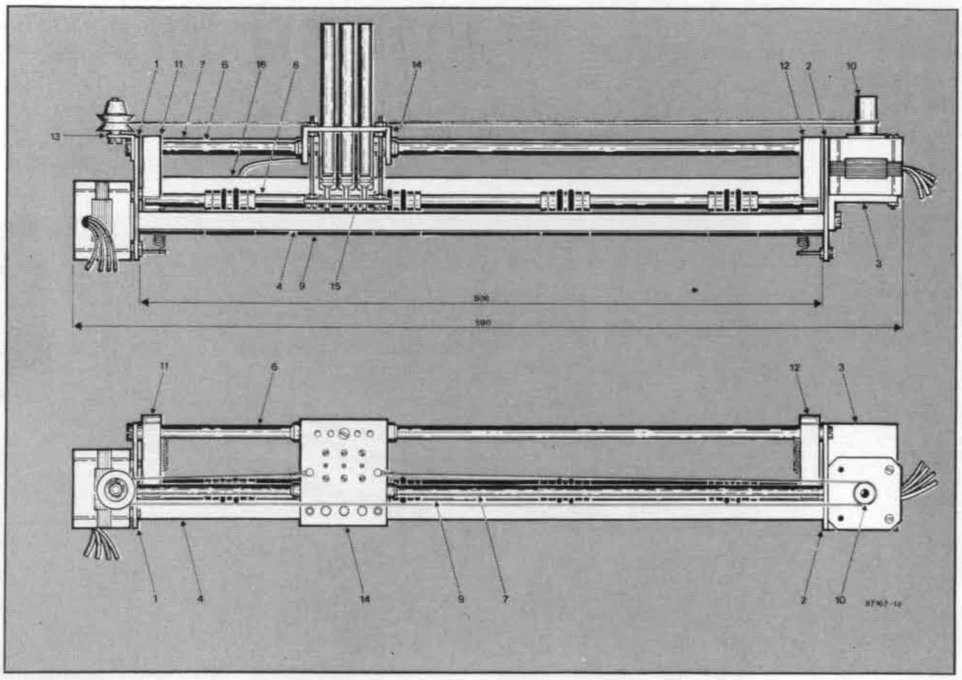


Fig. 1a. General parts identification of the plotter.

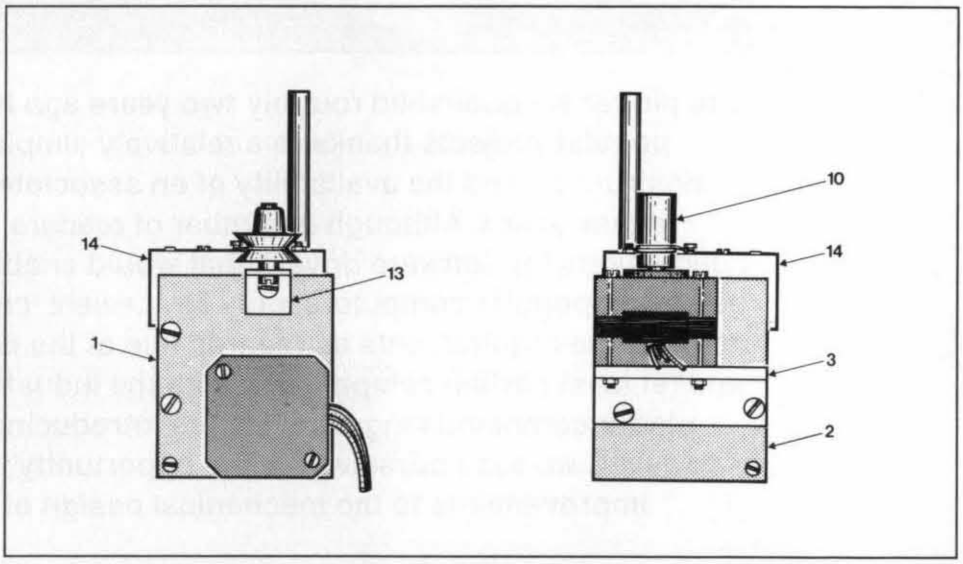


Fig. 1b. Parts identification for the side plates which hold the stepper motors.

bearings, and PTFE (teflon) for the rollers. The use of high-grade metals, however, requires a wide range of tools and other special materials from your local hardware shop, and, of course, access to a lathe.

The nylon string is a crucial part and requires special attention because it must be secured in a manner that eliminates any risk of slipping on the spindle of the X-motor. One string end is secured to the carriage at the side of the string wheel. From there, the string goes to the string wheel where it makes a left turn towards the X-motor. The carriage is pushed to the extreme left (X-motor side), and the string is wound on to the motor spindle (part id. 10) until one particular point in the string is always in contact with the spindle. This means that the total length of the wound part of the string is equal to or greater than the maximum X-distance that can be travelled by the carriage. The point in the string is secured at the top of the motor spindle with the aid of an M3 screw.

Software

The software driver developed for the plotter runs on IBM PCs and compatibles. The driver is written in Turbo-C (Borland version), and is capable of reading plot files with a reduced command set to the HPGL, Calcomp or Gould standard. The program converts the data and commands in these files into coordinate numbers in the relevant plot area before it sends, via the Centronics port, the necessary motor and pen control commands to the plotter driver board.

To be able to generate a usable plot file, the CAD program which is used to make the drawing must have plotter types

AS = 3	Number of pens
PW = 0	Pause at pen change (0/1)
WB = 100	Wait time after pen actuation (clock cycles; 1–255)
2X = 0	X-difference between pen 1 and pen 2 (–500–500)
2Y = 0	Y-difference between pen 1 and pen 2 (–500–500)
3X = 0	X-difference between pen 2 and pen 3 (–500–500)
3Y = 0	Y difference between pen 2 and pen 3 (–500–500)
MX = 1700	Maximum X-coordinate (0–1000)
MY = 2000	Maximum Y-coordinate (0–10000)
SD = 4	Step duration (clock cycles; 1–255)
SS = 1	Parallel port number (1/2)
GS = 0	Full-step mode
PT = 55	System clock (1–255)
LA = 1	Loudspeaker on/off (0/1)
BV = 1	Slow/fast (0/1)
PS = 1	Plot language (1=Calcomp; 2=Gould; 3=HPGL)
RA = 1	Draw frame (0/1/2)
SX = 100	X-scale (1–1000%)
SY = 100	Y-scale (1–1000%)

Table 1. Parameters in the driver configuration file, MONDRIAN.SYS.

HP7220, Calcomp 81 or Gould 6200 in its device driver list. On completion of the drawing, the plot file is not sent direct to the Centronics port, but to a file which is temporarily stored on disk.

The plotter driver program, MONDRIAN.EXE, is called up with the plot file name as an extension, for instance:

MONDRIAN NOZZLE.CAL

To enable the driver program to find the plot file, it must either be listed in the same subdirectory, or the PATH configuration must be set accordingly.

The program starts with a menu screen which shows the current options and parameters. The lower window on the screen shows the plotter commands as they are read and converted.

The program works on two tasks in a quasi-simultaneous manner: the conversion of plot coordinates into step pulses for the motors, and, in the background, the sending of calculated values to the plotter control board via the Centronics interface. A problem may arise from the assignment of processor time to these tasks. If the calculations run too fast, the plotter forms a bottleneck after a relatively short time. Conversely, if the calculations run much slower than the actual plotter control, the plotter wastes time waiting for new commands from the computer. The time sharing problem is eliminated by an auxiliary program, REALTIME.COM, which establishes an optimum time ratio for the two processes on the basis of the computer type used.

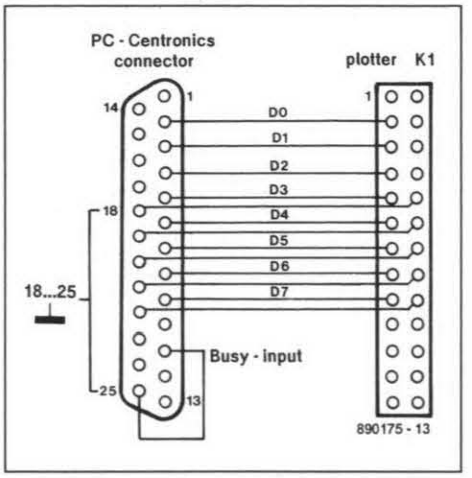


Fig. 2. Connections between the PC Centronics port and the input of the plotter driver board.

The driver program may be called up with a test switch:

MONDRIAN /T

to check quickly and without wasting paper whether the drawing fits on the required paper size. If not, the scale factors must be modified accordingly.

Parameters and configuration file

The plotter driver program is simple to configure for different mechanical constructions (as already noted, the constructor determines his own plotter width). The configuration file on the disk, MONDRIAN.SYS, contains the start parameters — an example is shown in Table 1. The file contains ASCII characters only and may be edited with a word processor. Each line starts with a two-letter parameter identification and a default value, which can take up to three digits. As shown in the example, each line is made complete with comment.

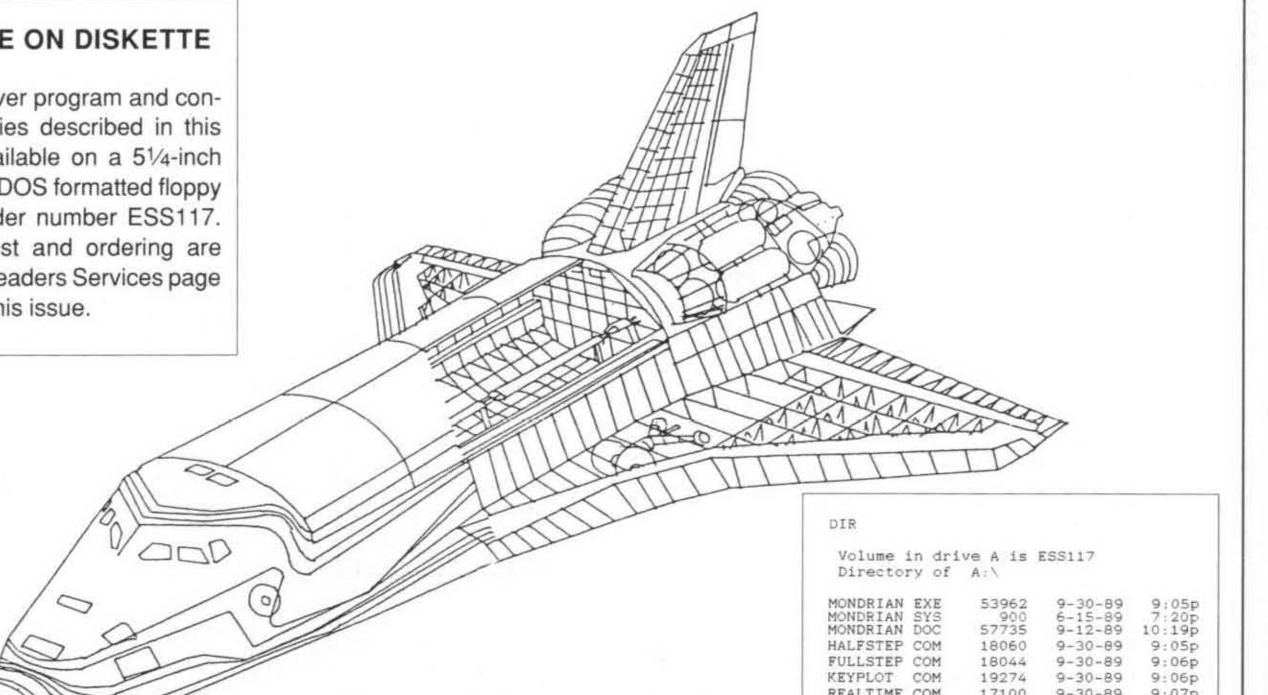
When called up, the control program searches for MONDRIAN.SYS and loads the user-defined configuration. If the file can not be found, default values are adopted for the parameters otherwise loaded from MONDRIAN.SYS. A fair number of configuration options is available, from the number of pens to the zoom factor and the plot language. The nX parameters (X-Y difference) allow drilling inaccuracies in the pen holes to be compensated: in this manner, the inaccuracy caused by a pen (= colour) change can be kept smaller than 0.1 mm.

Limitations

It should be noted that version 1.0 of MONDRIAN.EXE recognizes only six HPGL (Hewlett-Packard Graphics Language) commands, while the language has many more. The same goes for the Calcomp and Gould formats: only six commands are supported. Fortunately, many problems caused by this limitation may be prevented by using the right plotter driver. Most CAD programs allow the user to select a particular plotter driver from a menu during installation of the

SOFTWARE ON DISKETTE

The plotter driver program and configuration utilities described in this article are available on a 5¼-inch 360 KByte MSDOS formatted floppy disk under order number ESS117. Details on cost and ordering are given on the Readers Services page elsewhere in this issue.



```
DIR

 Volume in drive A is ESS117
 Directory of  A:\

MONDRIAN EXE    53962   9-30-89   9:05p
MONDRIAN SYS      900   6-15-89   7:20p
MONDRIAN DOC    57735   9-12-89  10:19p
HALFSTEP COM    18060   9-30-89   9:05p
FULLSTEP COM    18044   9-30-89   9:06p
KEYPLOT  COM    19274   9-30-89   9:06p
REALTIME COM    17100   9-30-89   9:07p
READPLOT COM    15380   9-30-89   9:07p
3COLORS  CAL     1764   5-15-89   8:19p
TESTPENS CAL      223   5-15-89   9:08p
NOZZLE   CAL    55213   5-15-89   8:38p
COLUMBIA CAL    25984   5-15-89   8:44p
ESCHER   CAL     9489   6-11-89  10:58a
README            957   9-30-89   9:02p
MONDRIAN MSG     2647   1-03-90   8:52a
UTILITY  MSG     2076   1-03-90   9:03a
       16 File(s)     56320 bytes free
```

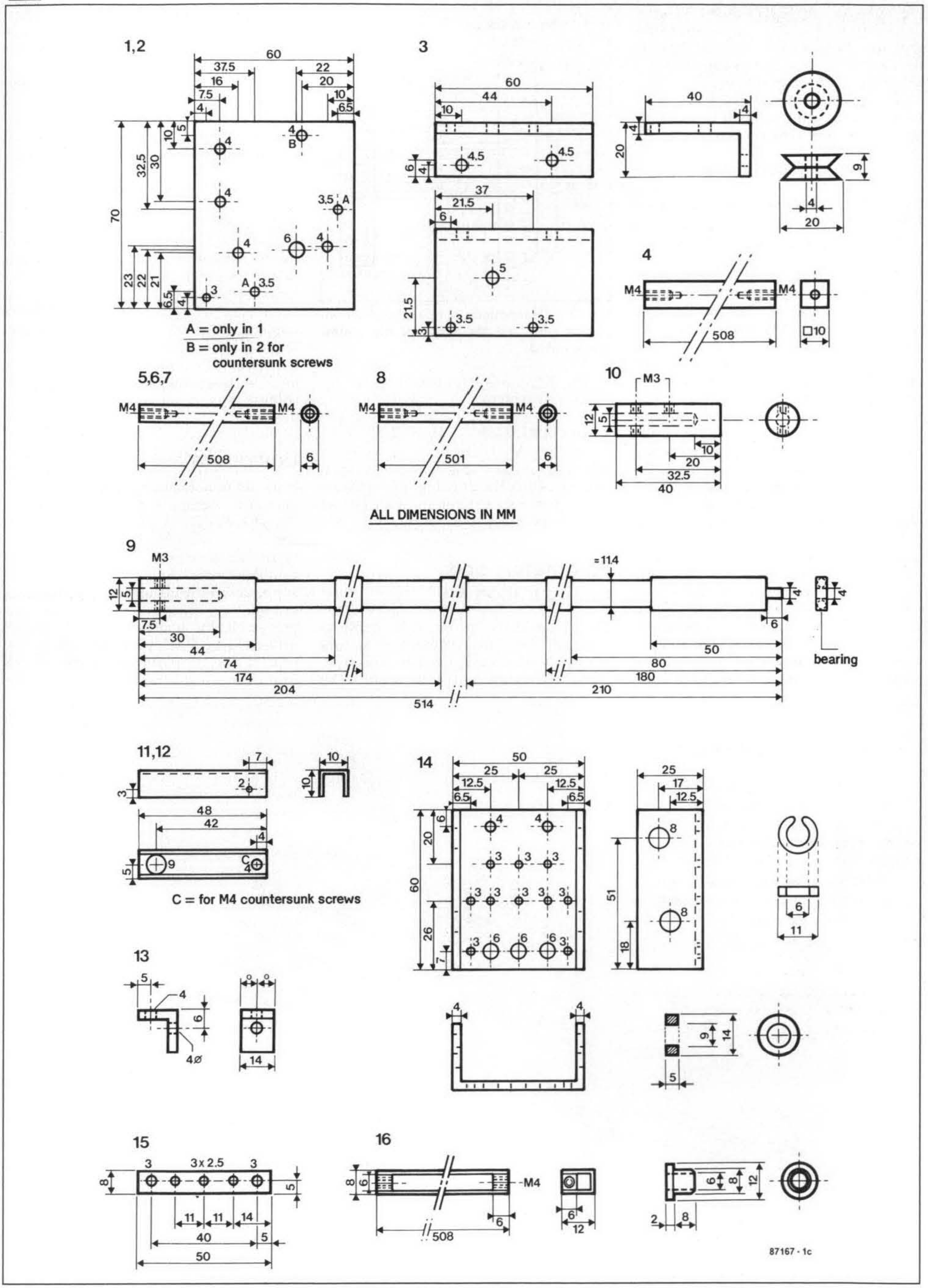


Fig. 3. Dimensions of all nylon and aluminium or stainless steel parts that must be cut, filed, turned and drilled.

MECHANICAL PARTS LIST

(all dimensions in mm)

1. side plate; left; aluminium; 60×70×3 mm.
2. side plate; right; aluminium; 60×70×3 mm.
3. angled support bracket for X motor; L-shaped aluminium; 20×40×4 mm; length 60 mm.
4. square connection bar; aluminium 10×10 mm; 508 mm long.
5. round connection bar; aluminium/stainless steel rod; dia. 6 mm; 508 mm long.
6. round support bar for pen carriage; dimensions as 5.
7. round guide bar for pen carriage; dimensions as 5.
8. round bar for pressure rolls; aluminium/stainless steel rod; dia. 6 mm; length 501 mm.
9. platen; round aluminium bar; dia. 12 mm; length 514 mm.
10. shaft; aluminium; dia. 12 mm; length 40 mm.
11. tilt lever for pressure rolls spindle; U-shaped aluminium beam 10×10×1 mm; length 48 mm.
12. see 11).
13. angled support bracket for string wheel; U-shaped aluminium beam 15×15×2 mm; length 14 mm.
14. pen carriage; U-shaped aluminium beam 25×50×3 mm; length 60 mm.
15. pen positioning plate; aluminium; 8×50×2 mm.
16. cable guide; U-shaped aluminium beam 12×8 mm; length 508 mm.

Miscellaneous parts:

6 off slide bearings; nylon; Skiffy 08-6.
1 off bushing for platen; nylon; Skiffy 08-4 or 08-6, or suitable ball bearing.
2 off washer rings for Y-motor; internal dia. 3 mm; thickness 2 mm.
2 off rubber pressure rolls (e.g. cable grommet).
4 off fixing rings for dia. 6 mm spindle (e.g. Skiffy 11-1-6).
1 off string wheel.
3 off cylinder head screws M4×5.
2 off cylinder head screws M4×10 (for fixing part no. 3).
1 off cylinder head screw M4×20 with 3 nuts.
5 off M4×5 screws with countersunk head.
4 off cylinder head screws M3×40 (for fixing stepper motors).
2 off cylinder head screws M3×50 (for fixing part no. 15).
2 off cylinder head screws M3×10 (for fixing string).
2 off cylinder head screws M3×15 (for fixing spring brackets).
4 off headless adjustment screws M3×3 (for fixing part nos. 9 and 10).
6 off bolts M2.6×5 (for fixing pen lift magnets).
16 off hexagonal nuts M3.
2 off springs for pressure rolls spindle.
string; e.g., wound fishing line
fine grade sandpaper (for securing on platen).

Electromechanical parts:

2 off stepper motors; 200 steps/rev.; dual-phase bipolar; 200 mA/phase (e.g. Berger as used in disk drives).
3 off pen lift electromagnets; 12 V; e.g. Binder Magnete Type 40031-09B00.

Distributor of Skiffy products in the UK is Salterfix Fasteners • Salter Springs & Pressings Limited • Spring Road • Smethwick • Warley • West Midlands B66 1PF. Telephone: (021 553) 2929. Telex: 337877.

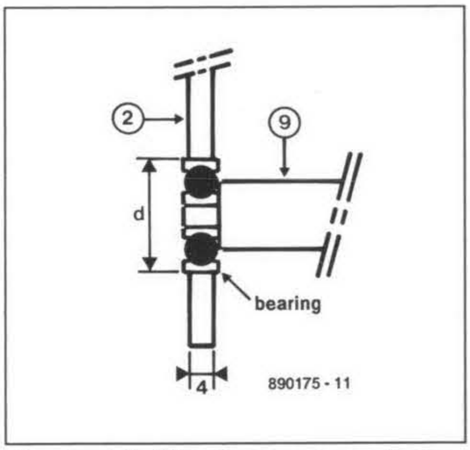


Fig. 4. A ball-bearing may be used where the plate is secured to the side plate.

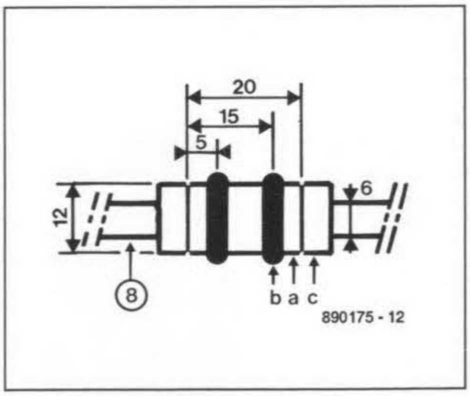


Fig. 5. Detailed construction of a paper roll.

package. Programs like AutoCad and AutoSketch, for instance, use only six plot commands if a Hewlett Packard plotter is installed: circles and ellipsoids are drawn with the aid of MOVE and PLOT sequences rather than with the much more powerful ARC command. This means that only a subset of basic HPGL commands is used. Since the present driver program, MONDRIAN.EXE, is capable of handling the six basic commands, it should be suitable for many CAD packages, provided they can be configured to save plot files with the reduced set of HPGL commands. ■

Reference:

1. Plotter. *Elektor Electronics* May 1988 and June 1988.

```
Elektor Plotter Driver     Version 1.0    (c) Copyright by Elektor, 1989

stop at new pens          OFF    file name                 nozzle.cal
full-step                 OFF    plot commands             CALCOMP
speaker                   ON     frame size                1700/2000
speed up/slow down        ON     scaling                   100%/100%
frame                     ON     clock                     0.99 ms
number of pens            3      clocks per step           4
parallel interface        1      clocks per pen movement100

    41 : 1347/1115K      move to :1347/1115
    42 : H               pen up
    43 : 1325/1123K      move to :1325/1123
    44 : I               pen down
    45 : 1174/1274K      move to :1174/1274
    46 : 1168/1282K      move to :1168/1282
    47 : 1167/1291K      move to :1167/1291
    48 : 1168/1300K      move to :1168/1300
    49 : 1174/1308K      move to :1174/1308
    50 : 1659/1794K      move to :1659/1794
    51 : H               pen up

continue - press any key...       c - cancel  p - pause  s - stop
```

Fig. 6. Screen dump of the plotter driver program, MONDRIAN.EXE.

DIGITAL TRIGGER FOR OSCILLOSCOPES

A. Rigby

The circuit described here enables an oscilloscope to be triggered when a predetermined binary code word is applied to one of the circuit's inputs.

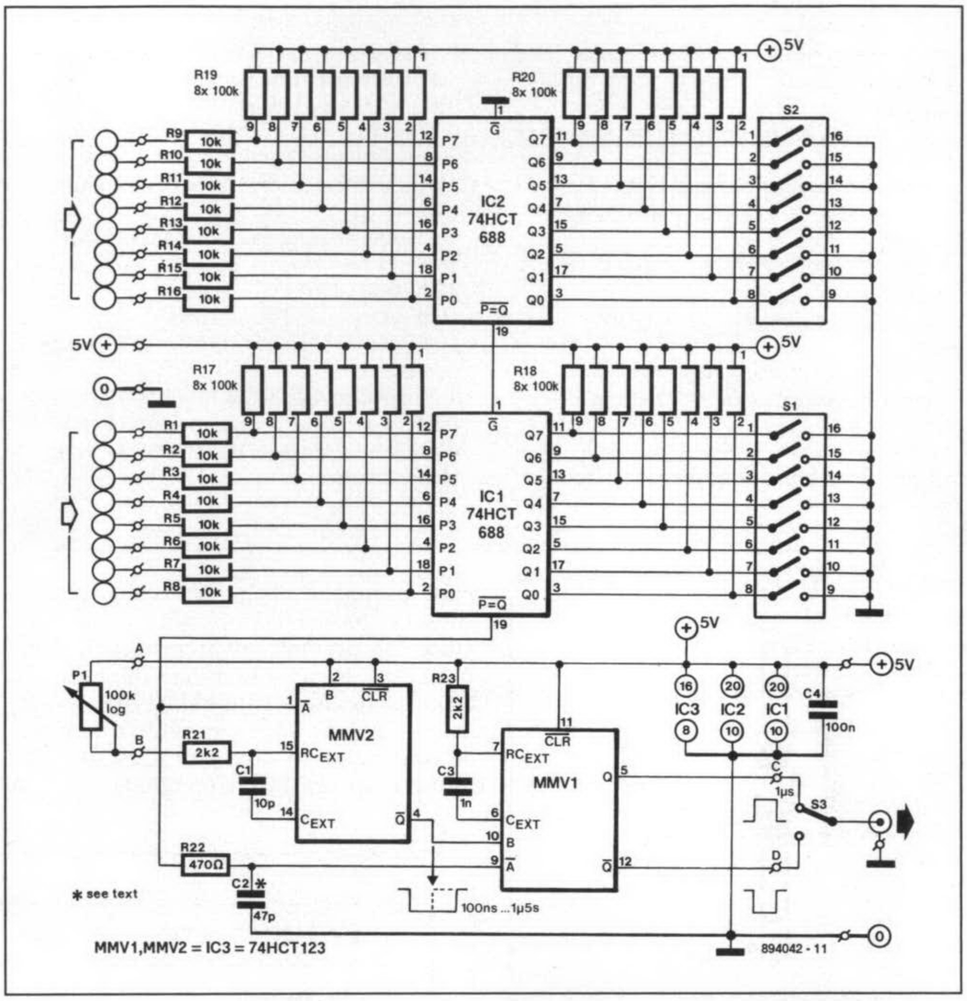
Integrated circuits IC_1 and IC_2 compare the 16 input levels with the code set by switches S_1 and S_2. If one of the inputs has a dataword that is equal for not less than 100 ns to that set by S_1 and S_2, pin 19 of IC_1 goes high. Note that, because of the pull-up resistors, open inputs are treated as high.

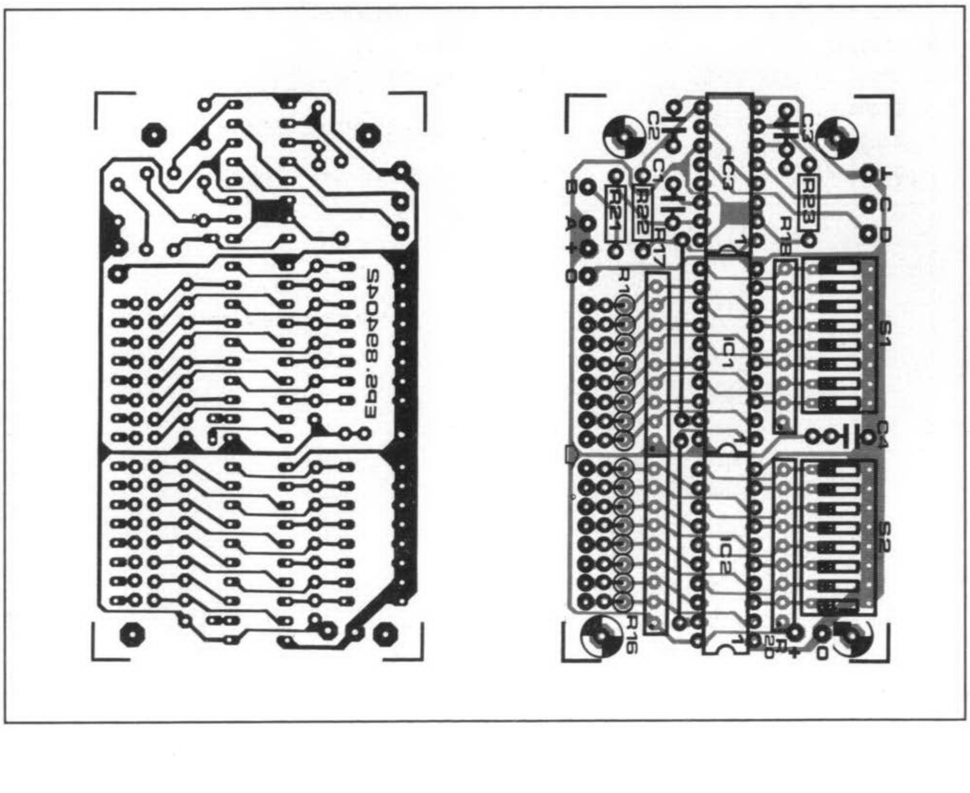
When pin 9 of IC_1 is high, monostable MMV_2 is triggered and outputs a negative pulse from its pin 4. The length of this pulse is 0.1–1.5 µs, depending on the setting of P_1. If during that time the predetermined trigger value disappears, no triggering takes place. Potentiometer P_1 is a logarithmic type to enable very short times to be set accurately.

The output pulse from MMV_2 triggers a second monostable, MMV_1, whose monotime has been set to 1 µs by R_{23}-C_3.

Either the positive signal from the Q output or the negative signal from the $\overline{Q}$ output, depending on the setting of S_3, may be applied to the oscilloscope.

The printed circuit board is relatively small. Most resistors are mounted upright. If difficult to obtain locally, the four single-in-line (SIL) resistor arrays may each be replaced by eight vertically fitted resistors whose top wires are cut short for connecting to a horizontally running wire to the +5 V line. ■





COMPONENTS LIST

Resistors:
R_1–R_{16} = 10k
R_{17}–R_{20} = 100k
R_{21};R_{23} = 2k2
R_{22} = 470 Ω
P_1 = 100k logarithmic potentiometer

Capacitors:
C_1 = 10p
C_2 = 47p
C_3 = 1n0
C_4 = 100n

Semiconductors:
IC_1;IC_2 = 74HCT688
IC_3 = 74HCT123

Miscellaneous:
S_1;S_2 = 8-way DIP switch.
S_3 = miniature SPDT switch.
K_1 = BNC socket.
Qty. 18: miniature test clip.
Enclosure: e.g., OKW A9010 065
PCB 894042

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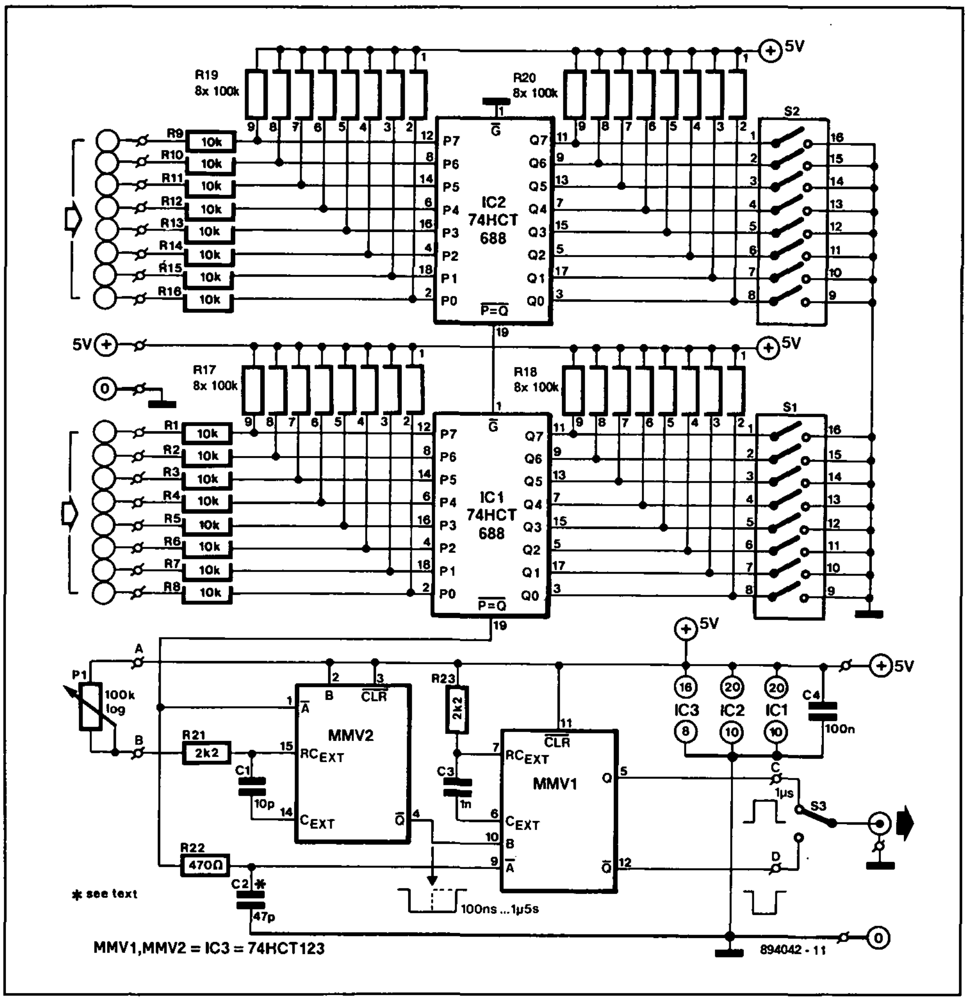

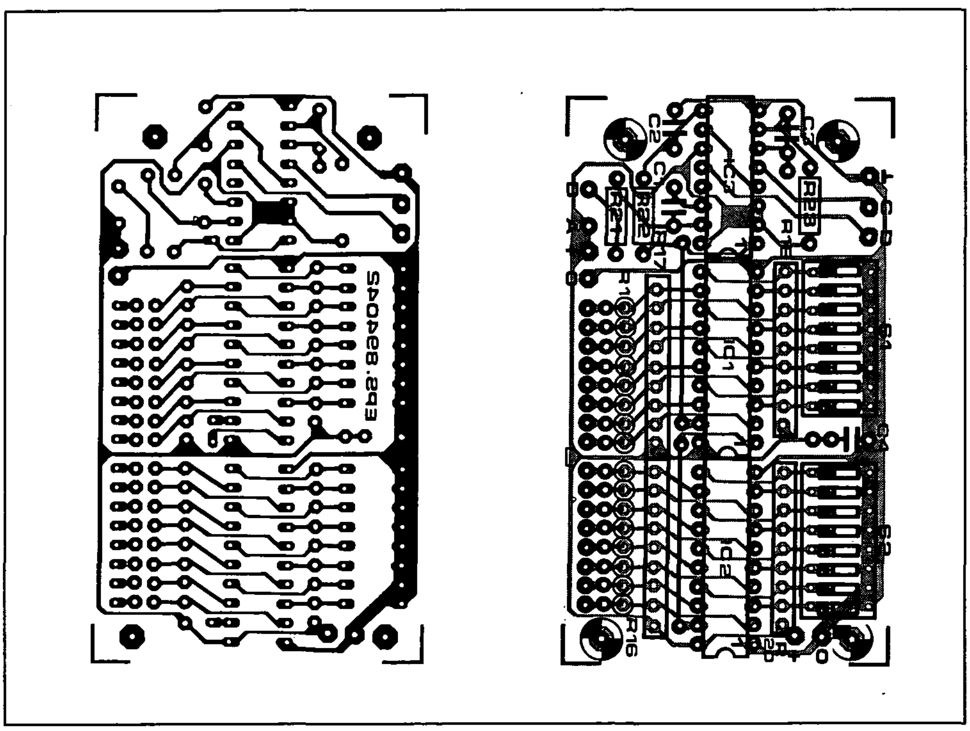

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EXPERIMENTAL BSB RECEPTION

R.G. Krijgsman PE1CHY, J.C. Stekelenburg PE1FYZ and J. Buiting PE1CSI

A wave of publicity recently swept over the UK announcing the launch of the five-channel BSB TV-satellite. Everybody seems to have an opinion on this event, and pages of comment have been written on it, even in technical magazines, without proof of the availability of receive equipment. The bottlenecks are, as we learn from informed sources, the aerial and the D-MAC set-top decoder. Well, squarial or no squarial, *Elektor Electronics* is proud to be the first international electronics publication to present pictures of MAC transmissions received from BSB and other DB satellites. Rather than gazing into a crystal ball, we show you a glimpse of a multi-standard MAC decoder for home construction that is currently being designed.

At the time of writing (mid-January 1990), the launch of BSB's five high-power TV channels is due this spring. From a technical point of view, BSB offers two novelties: D-MAC and the flat dish or squarial. Other technical aspects such as the use of the DBS frequency band (11.7–12.5 GHz), circular polarization and medium-level transmit powers (approx. 55 dBW) will certainly be new for many satellite-TV enthusiasts, but are familiar from other broadcast services which have been in use for over a year already. DFS Kopernikus (23.5° E) has about the same transmit power as BSB, while both TDF-1 and TV-SAT2 use D2-MAC, high transmit powers (61 dBW) and circular polarization in the DBS band. Keen satellite-TV experimenters may also have noted the very strong signals from the two DBS TV transponders on board the Olympus satellite. One channel is currently allocated to RAI Italy, the other to British Telecom. The RAI channel is transmitted in PAL, while British Telecom alternately use PAL and D2-MAC, the latter for parts of the BBC-TV Europe programme. TDF-1, TV-SAT2 and Olympus are positioned at 19° west. BSB is positioned at 31° West, which is more favourable for the UK because it allows the satellite's spot-beam to cover the target area at roughly equal signal strength, and because the dish elevation is not too low.

Strong but unintelligible

Whatever the standard, C-, D- or D2-MAC, MAC pictures are totally unintelligible on standard PAL monitors and TV sets used by hundreds of thousands of satellite-TV viewers in Europe. This is because the MAC standard uses a totally different method of picture and sound transmission, which is partly digital and time-multiplexed rather than frequency-multiplexed. Although set-top decoders for MAC channels are not yet available, it is surprising to note how many non-technical dish owners are aware of the existence of the MAC system, and even the meaning of the acronym. This awareness must be partly due to two D2-MAC channels on the Astra TV satellite: Scansat TV-1000 and TV3 (one of which is encrypted at low level).

Both TV-SAT2 and TDF-1 are running experimental transmissions. TDF-1 has four transponders which are used for promotional purposes and technical experiments. TV-SAT2, the West-German DB satellite, carries four TV channels which run in parallel with DFS Kopernikus and Astra. Remarkably, some of the programme material on TV-SAT2 is in PAL, while the satellite transmits in D2-MAC. So much for technical improvements!

The transmissions received from BSB during its pre-operational use that started in December 1989 are also experimental. Three transponders are already encoded, and one is in 'clear' D-MAC. As could be expected, the signals are strong and totally noise-free.

Experimental equipment

The equipment used for making the accompanying colour photographs was assembled

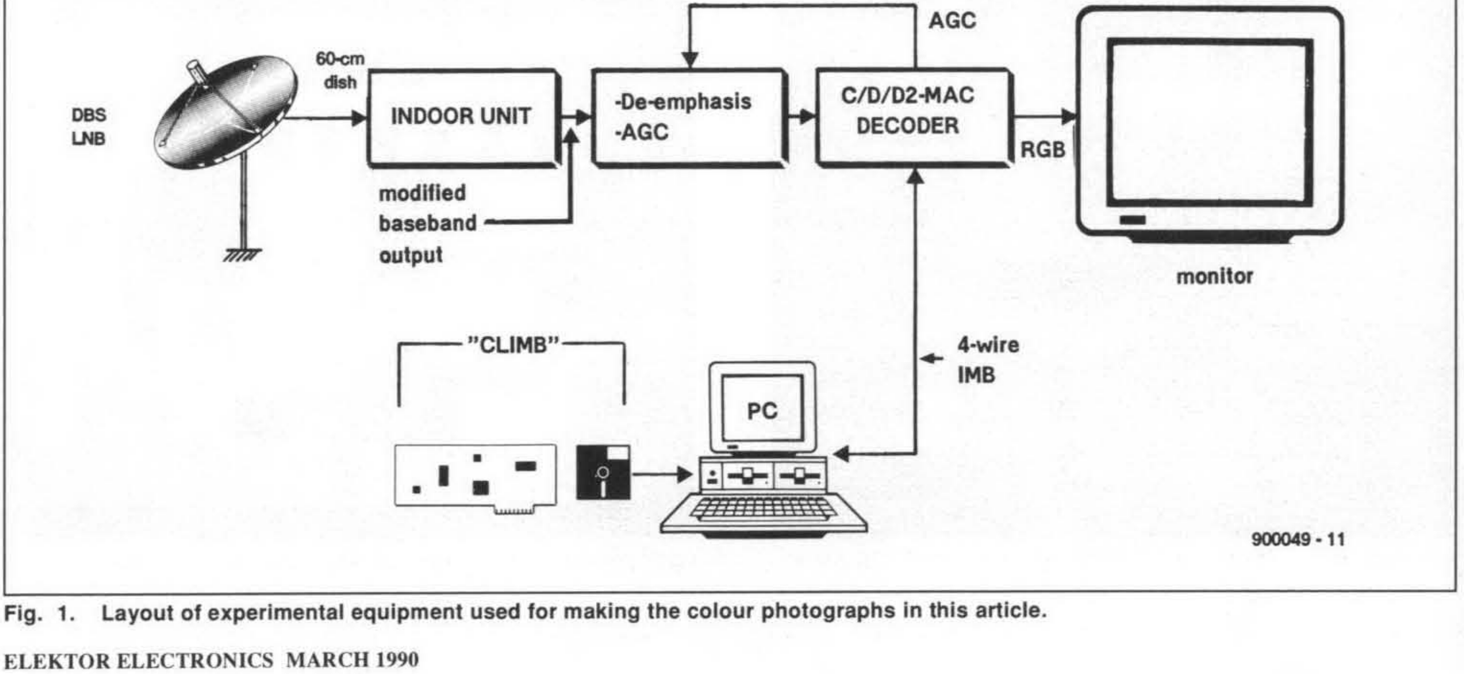
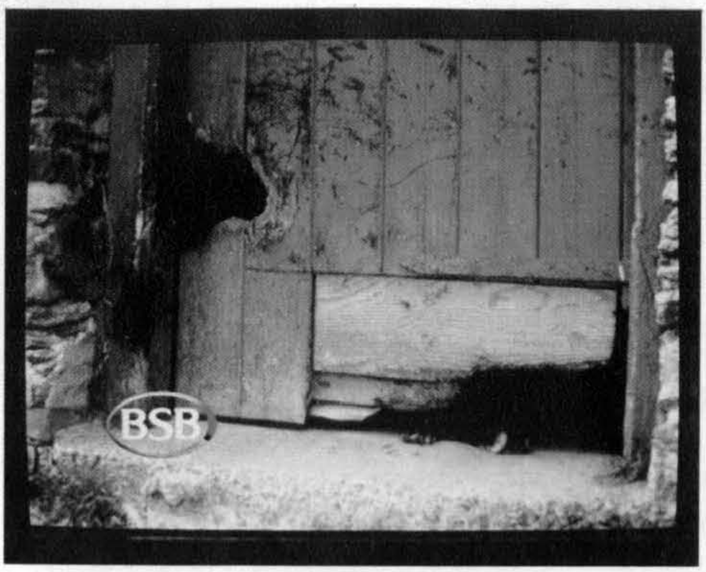
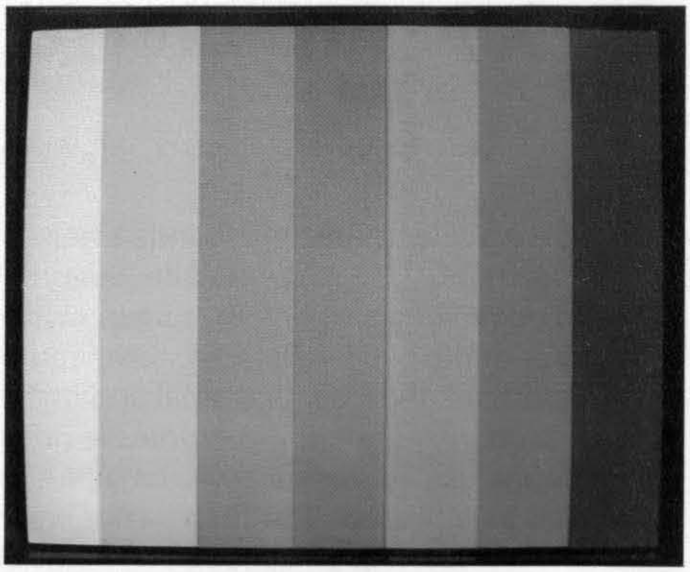


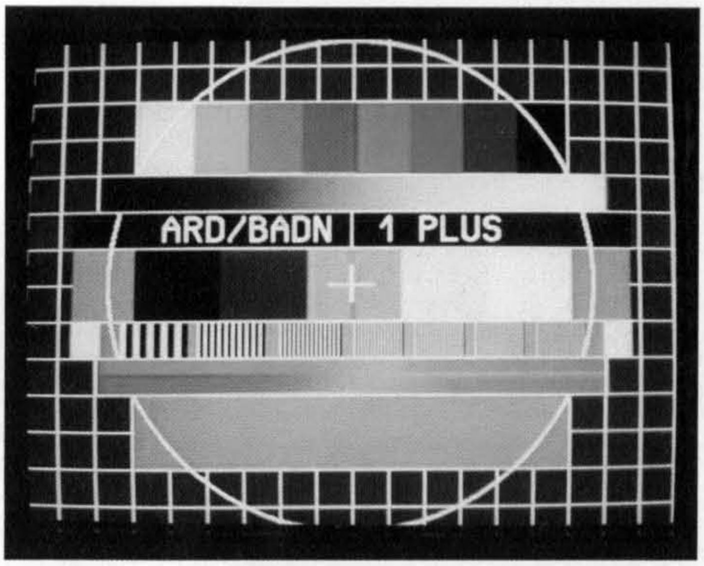
Fig. 1. Layout of experimental equipment used for making the colour photographs in this article.



Photograph 1. BSB still test picture (D-MAC).

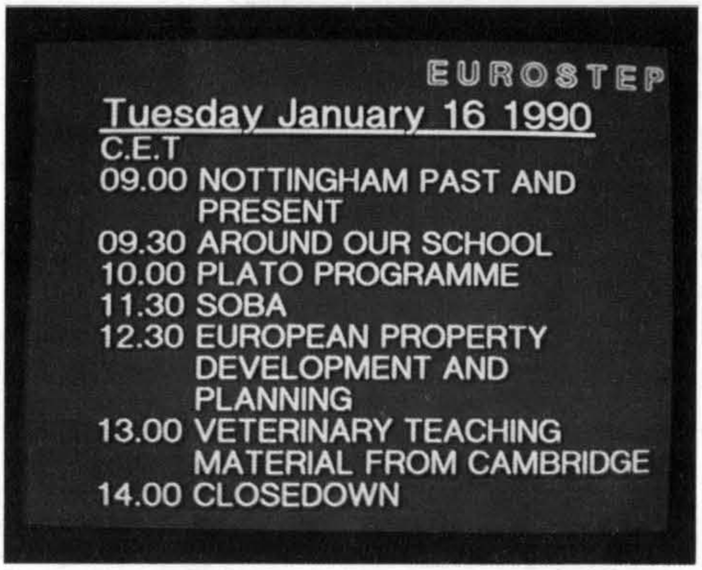


Photograph 2. BSB colour-bar test chart (D-MAC).

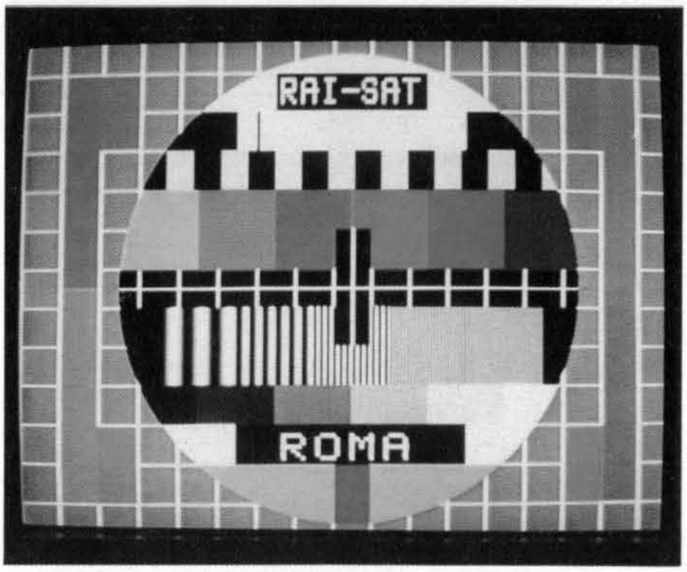


Photograph 3. ARD-1 Fu-Bk-type test chart (TV-SAT2; D2-MAC).

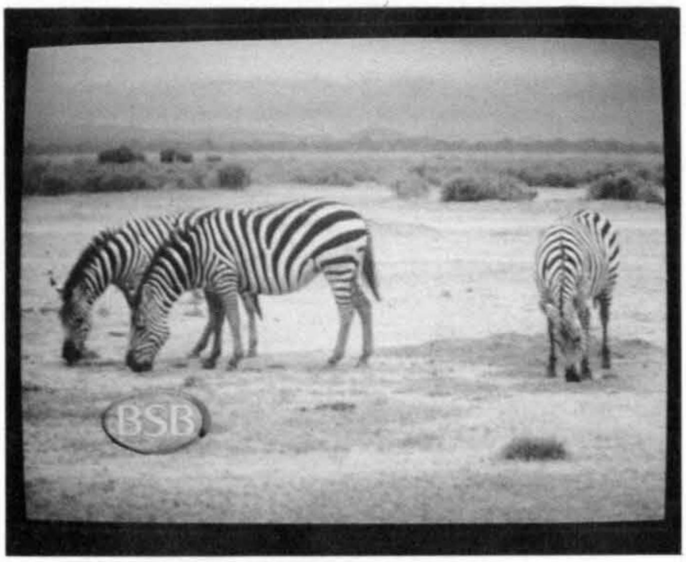
Photograph 4. TDF-1 station identification (D2-MAC).



Photograph 5. European info programme (D2-MAC; Olympus).



Photograph 6. RAI Fu-Bk-type test chart (PAL; Olympus).

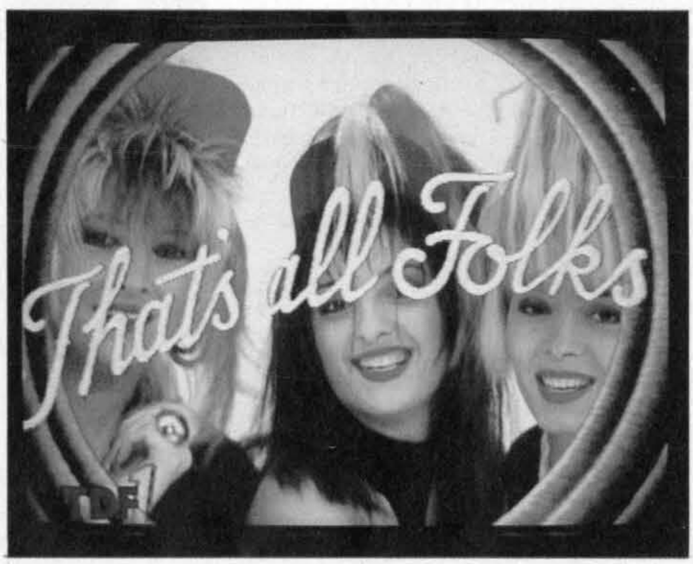


Photograph 7. BSB still test picture (D-MAC).

Photograph 8. Nordic-channel identification (ECS4; D2-MAC).

Photograph 9. Outdoor unit set up on a photographer's tripod in the garden.

Photograph 10. BSB still test picture (D-MAC).



Photograph 11. Video clip in brilliant colours on TDF-1 (D2-MAC).

Satellite	Position	Country	EIRP	Channels	TV standard	Programmes*
TV-SAT2	19° W	West-Germany	61 dBW	4 (lhc)	D2-MAC	Eins-Plus, 3-SAT, RTL-Plus, SAT-1
BSB-1	31° W	United Kingdom	55 dBW	5 (rhc)	D-MAC	The Movie Channel, The Sports Channel, Galaxy, Now, The Power Station
TDF-1	19° W	France	61 dBW	4 (rhc)	D2-MAC	Miscellaneous/ to be assigned
Olympus	19° W	UK/Italy	63 dBW	3 (lhc/rhc)	D2-MAC/PAL	RAI, B.T. World Service/BBC TV Europe/Discovery

* experimental services.
rhc = right-hand circular polarization. lhc = left-hand circular polarization.

experimentally to test a prototype of a multi-standard MAC decoder which is currenty being developed in the *Elektor Electronics* engineering department. A preliminary description of this unit, which we hope to publish later this year, is given further on.

The general layout of the equipment is shown in Fig. 1. The outdoor unit used for the experiments consists of a 60-cm off-set dish and a Type ST-980 LNB from Uniden. The latter is a fairly unique unit because it can be switched from CSS-band (10.95–11.75 GHz) to DBS-band (11.75–12.5 GHz) reception by means of two supply levels on the LNB downlead coax cable. The noise figure of this LNB is also remarkable at 1.9 dB. A linear polarizer could be used with impunity because there is (as yet) no interference from other satellites at the UK DBS position of 31° W (for the Euro-DBS position, 19° W, we use a piece of teflon in the round feed-horn to turn the linear polarizer with magnetic H/V selection into a circular feed). It must be noted, though, that the use of a linear polarizer for circular signals results in a signal degradation of at least 3 dB.

The indoor unit is a Type CX-8520R from Connexions. The baseband output of this receiver is modified to provide the large bandwidth required by the MAC decoder (insufficient bandwidth results in high bit-error correction rates).

Next in the configuration is a purpose-designed de-emphasis/AGC unit which is controlled by a digital signal supplied by the MAC decoder. This unit, which exists as an experimental design, is a quite elaborate circuit to meet the EBU specifications in respect of the de-emphasis for D-MAC as well as D2-MAC (these specifications are not the same as those used for PAL). The AGC function makes the operation of the de-emphasis section independent of the baseband signal level. This is an important aspect which ensures that many types of indoor unit can be used with the decoder.

What's cooking?

The heart of the system is formed by an experimental multi-standard MAC decoder based on the Type DMA2280 chip from ITT (Intermetall). The decoder, of which an inside view is shown in Fig. 2, is controlled over a 4-wire cable by a PC running the CLIMB (Command Language for InterMetall Bus) interpreter from Intermetall. This interpreter allows sequences of read/write operations to the nearly 100 registers in the chips on the decoder board to be given a program structure, and works in conjunction with a PC insertion card. The PC is, of course, required during the design stages only to establish the optimum program flow and register contents. If these parameters are known, almost any small microprocessor system can take over this task, running an EPROM-based program. The authors/designers are currently thinking of using a Z80 and some peripheral chips for this application.

The MAC decoder supplies RGB signals which are fed direct to a high-resolution monitor via its SCART input. Note that the decoder has registers for just about every picture setting, from colour saturation and brightness to horizontal sync delay and picture positioning. Remarkably, the decoder obviates anything to do with PAL, SECAM, or remodulators because it drives the RGB circuits in the TV direct to ensure the best possible picture resolution. The MAC decoder has an option for automatic 16:9-to-3:4 aspect ratio conversion, which allows future HDTV transmissions to be seen on a standard (3:4) TV set or monitor. Some experimental 16:9 transmissions have already been received from TDF-1.

Impressions

Talking about picture resolution, the quality of a real MAC picture (not a PAL programme transmitted in MAC) is impressive even if you are used to day-to-day TV reception at good quality. The colours in the still pictures and the test charts transmitted by the BSB are, in a word, brilliant, and do not suffer from boundary effects and other colour irregularities. Cross-colour and moiré effects are completely absent, and the picture resolution is suddenly 6.5 MHz as compared to a 'lousy' 3.5 MHz that can be resolved by most current PAL TV sets. Transitions between deep red and blue, notorious in the PAL system for their blurred picture areas, are sharp as never before (note the coloured oval in the BSB logo, and R-to-B transition in the the TDF-1 ident). The sound accompanying the MAC programmes is in stereo at CD quality. Each BSB channel may have up to eight of these high-quality sound channels. ■

Colour photographs for this article made by Robert Krijgsman on 4 January 1990.

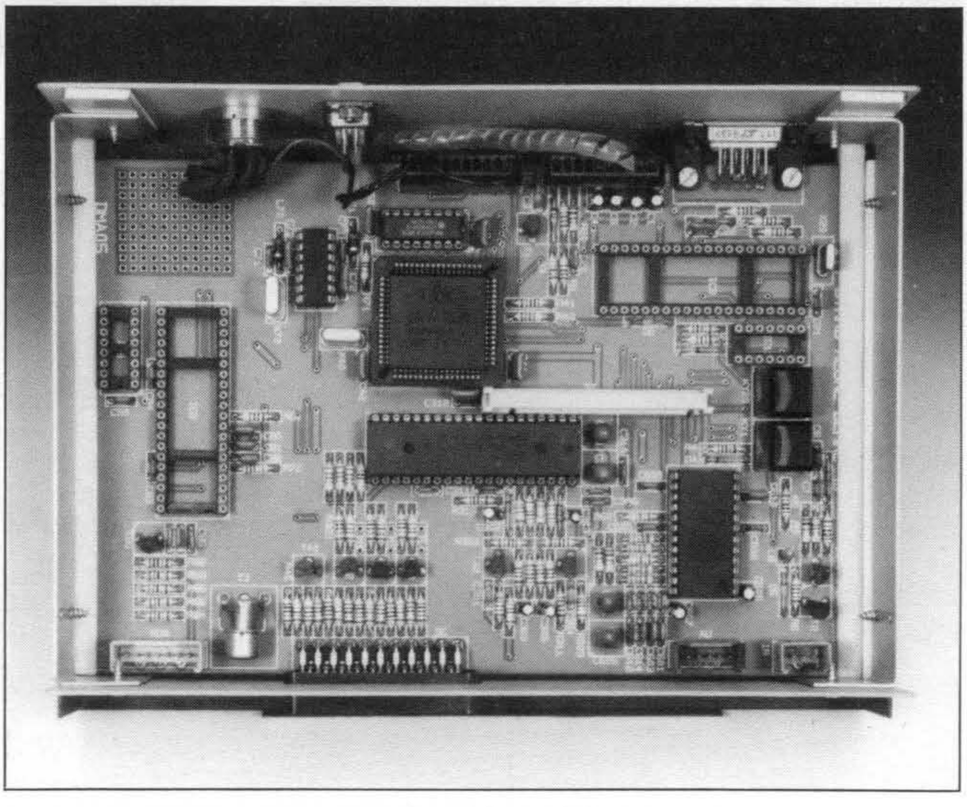


Fig. 2. Inside view of the prototype multi-MAC decoder.

POWER LINE MONITOR

J. Ruffell

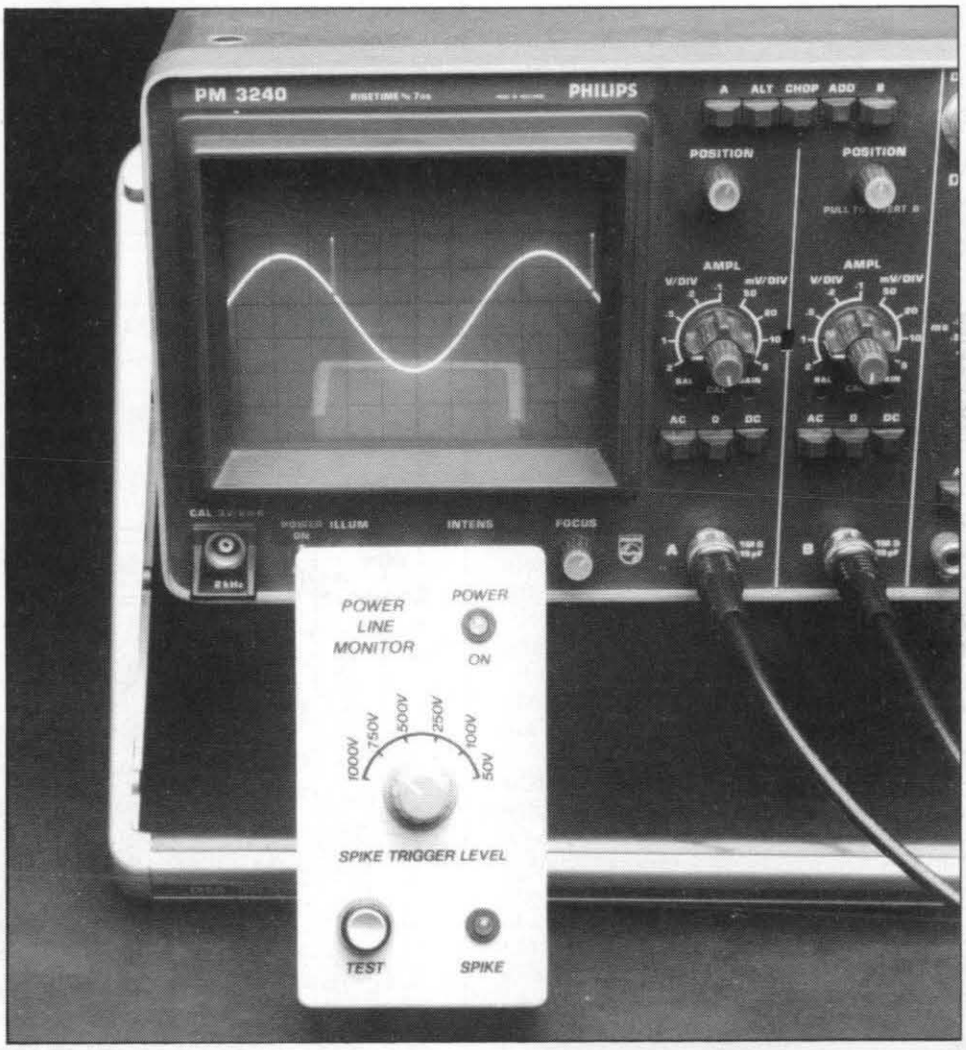
Most of us are aware that computers and other digital systems can go haywire just like that. If neither the hardware nor the software can be blamed for the hang-up, spikes on the mains voltage are the most likely cause of the trouble. The power line monitor described here enables you to determine whether or not spikes occur frequently on a particular mains outlet, and whether or not digital equipment needs to be powered via a mains filter to reduce the risk of hang-ups or total break-downs.

Sudden transient disturbances of the mains voltage are commonly referred to as surges or spikes. Since their peak voltage can exceed the normal mains voltage by hundreds of volts, it is not surprising that mains-powered equipment behaves erratically or breaks down altogether. Unfortunately, the occurrence of spikes is fairly difficult to record reliably, the reasons for which are mainly:

- the occurrence of a spike is difficult to predict;
- the voltage rise has a very short duration (typ. 10–500 ns);
- voltage peaks in excess of 1,000 V are no exception;
- the recording instrument must be connected to the mains line.

Principle of operation

The principle behind the power line monitor is shown in Fig. 1. Resistor R_9 forms a load for the rectified mains voltage. Assuming that the mains frequency is 50 Hz, the frequency of the voltage on R_9 is 100 Hz because a full-wave rectifier, D_1-D_4, is used. Spikes typically have a much higher frequency and are, therefore, readily detected with the aid of a high-pass filter, C_1-R_t, where R_t is the input resistance of the detector circuit. The 3 dB roll-off frequency of this high-pass is about 16 kHz, while its time-constant, τ, equals R_tC_1=10 µs. The function of R_9 may be less obvious in this basic circuit. Without it, however, C_1 would be charged to the peak value of the mains voltage (approx. 340 V). This would cause the diodes in the bridge rectifier to start conducting again if the mains voltage rises above this peak value. As a result, a 200-V spike during the mains zero crossing could not be detected since it would end up in the bridge rectifier. R_9 is, therefore, fitted to ensure that the voltage on C_1 follows the rectified voltage accurately. Hence, spikes are not



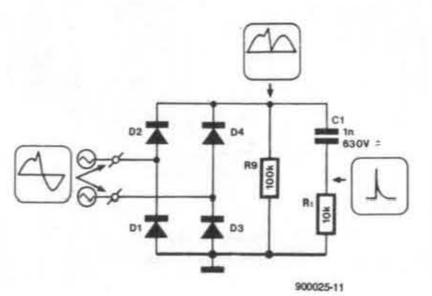


Fig. 1. Principle of spike detection.

MAIN SPECIFICATIONS

- trigger level adjustable in six steps: 50 V; 100 V; 250 V; 500 V; 1000 V
- response time: <50 ns
- potential-free detector output via opto-coupler ($U_{CE(max)}$=32 V)
- built-in mains power supply
- visual and audible spike indication

blocked by the rectifier, and they are too fast to be 'followed' by C_1. The result is that each and every spike or dip on the mains voltage appears across R_t. Dips, however, are ignored by the detector circuit.

Circuit description

Figure 2 shows the circuit diagram of the power line monitor. The mains voltage is rectified by a bridge circuit composed of four diodes Type 1N4007. This diode is used because of its peak reverse voltage specification of 1,500 V. The value of R_9 is a compromise between acceptable dissipation and sufficient loading of C_1. The high-pass filter is formed by C_1 and R_1-R_8. The minimum working voltage of C_1 must be 630 VDC since the device has on it the rectified voltage of about 340 V. The resistor ladder network, R_1-R_8, has only the spikes across it.

The ladder network and the associated rotary switch allow spikes at a certain level to be attenuated before they are applied to the trigger input of the detector, IC_{1b}, via the pole of S_1. A Type 74HCT221 dual MMV is used because of the following specifications, of which the importance is undisputed in the application circuit:

- the inputs are protected up to 2.5 kV typical;
- the input capacitance is low at 3.5 pF typical;
- the minimum width of the trigger pulse is 14 ns;
- the trigger level is accurately defined at 1.3 V, which enables a simple voltage divider to be used.

Note, however, that the actual minimum trigger pulse width is determined by the input attenuator and the stray capacitance of the input protection diodes, D_9-D_{10}, and the trigger input of IC_{1b}. This R-C combination forms a low-pass filter that causes spikes to be detected only if they are longer than 50 µs.

Monostable multivibrator (MMV) IC_{1b} is triggered when the attenuated spike voltage exceeds the trigger threshold set with S_1. On triggering, outputs Q and $\overline{Q}$ supply a 20-ms pulse. The pulse at the Q output is fed to IC_{1a}, which lengthens it to about 1 second. During this time, LED D_{11} and buzzer Bz_1 signal the occurrence of a

OPERATION AND CONTROLS

Range switch (S_1): set to expected spike level. Spikes exceeding set level are detected and indicated.

Test switch (S_2): press to test trigger function (manual trigger)

LED (D_5): on/off Indicator

LED D_{11} and buzzer Bz_1: spike indicators

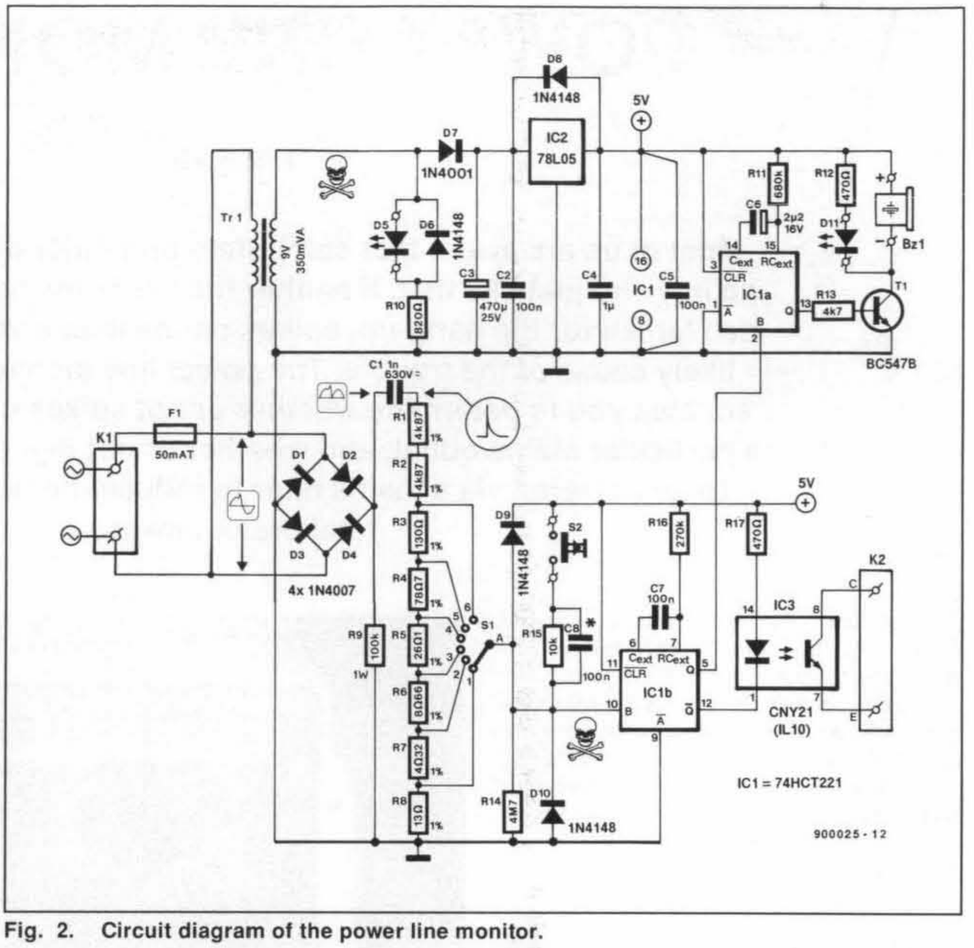


Fig. 2. Circuit diagram of the power line monitor.

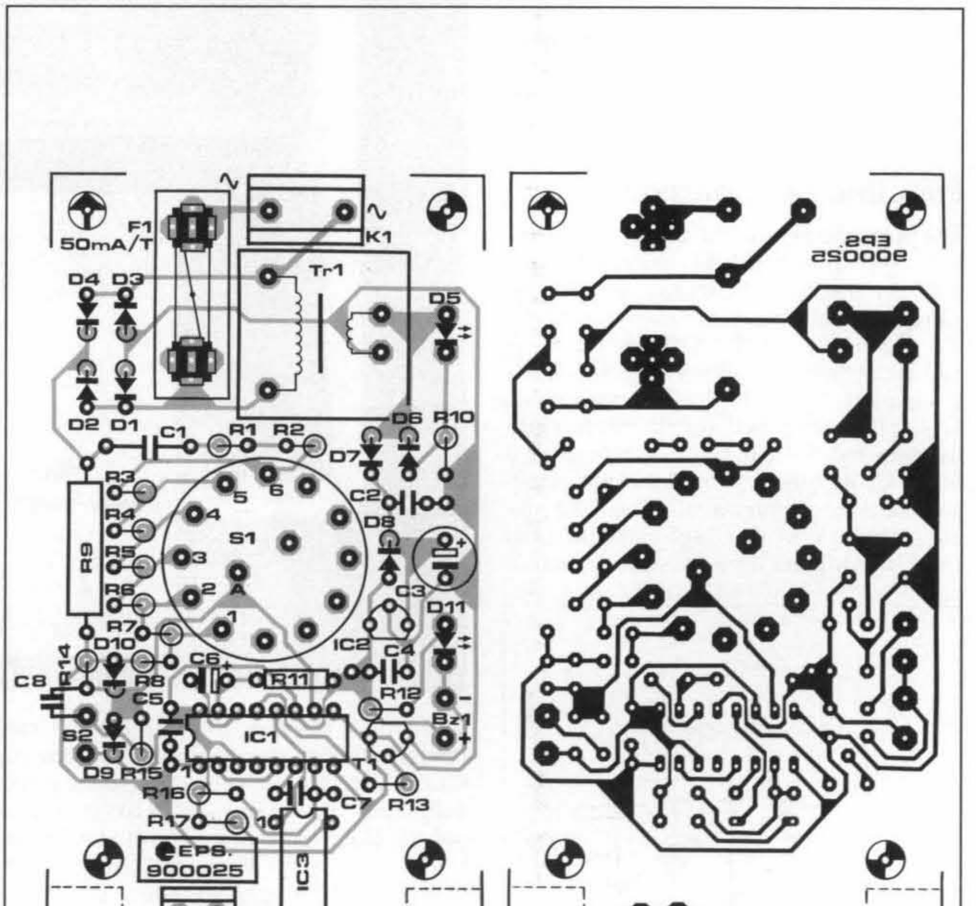


Fig. 3. Printed-circuit board overlay and track lay-out (reflected).

COMPONENTS LIST

Resistors:
R_1;R_2 = 4k87 1%
R_3 = 130Ω 1%
R_4 = 78R7 1%
R_5 = 26R1 1%
R_6 = 8Ω66 1%
R_7 = 4Ω32 1%
R_8 = 13Ω 1%
R_9 = 100k 1 W
R_{10} = 820Ω
R_{11} = 680k
R_{12};R_{17} = 470Ω
R_{13} = 4k7
R_{14} = 4M7
R_{15} = 10k
R_{16} = 270k

Capacitors:
C_1 = 1n0; 630 V
C_2;C_5;C_7 = 100n
C3 = 470μ; 25 V; radial
C_4 = 1μ0
C_6 = 2μ2; 16 V; radial
C_8 = 100n

Semiconductors:
D_1 – D_4 = 1N4007
D_5 = LED 5 mm green
D_6;D_8;D_9;D_{10} = 1N4148
D_7 = 1N4001
D_{11} = LED; 5 mm; red
T_1 = BC547B
IC_1 = 74HCT221
IC_2 = 78L05
IC_3 = CNY21 or IL10 (Siemens; Electro-Value Ltd.)

Miscellaneous:
S_1 = 2-pole 6-way rotary switch for PCB mounting; plastic spindle.
S_2 = miniature push-to-make button.
Bz_1 = 5-V active buzzer.
F_1 = fuse; 50 mA; slow; with PCB-mount holder.
Tr_1 = 9 V/0.35 VA mains transformer.
K_1 = 2-way mains-rated terminal block.
K_2 = 2-way terminal block.
ABS mains supply case; outside dimensions: 120×65×40 mm.
PCB Type 900025 (see Readers Services page).

spike. The detection circuit may be tested by pressing S_2; this causes IC_{1b} to be triggered manually.

The $\overline{Q}$ output of IC_{1b} drives an optocoupler, IC_3, to create a potential-free output, i.e., an output that is not at mains potential and, therefore, safe (within limits) for connection to other equipment. Connector K_2 may be wired to the input of, for instance, an event counter to establish the number of spikes that occur during a certain period. The output may also be used to stop a digital clock, or for other time-keeping purposes, to enable the origin of the spike to be traced. Another application is the use of a storage oscilloscope to determine when and why a particular computer broke down owing to a mains surge.

Because of the limited drive capacity of the 74HCT221, the LED in the optocoupler is not fed with its maximum current. This means that the external collector resistor for the optocoupler must not be smaller than 10 kΩ to ensure that the phototransistor is just driven into saturation.

Be sure to connect the external collector resistor and the emitter of the optocoupler to the positive supply and ground respectively of the recording equipment (whether digital or analogue), **never** to the +5 V and ground lines of the power line monitor, since these may be at mains potential.

The +5 V voltage for the power line monitor is provided by a standard power supply based on a mains transformer and a fixed-voltage regulator, IC_2. Note that the use of this supply does **not** mean that the low-voltage part of the circuit is safe to touch.

Construction and initial test

With safety in mind, it is best to construct the circuit on the printed-circuit board shown in Fig. 3. This board is mounted into a so-called power supply enclosure which is supplied complete with line and neutral pins for plugging into a mains outlet.

Capacitor C_8 is not shown on the overlay, but may be connected in parallel with R_{15} at the track side of the board. The rotary switch must be a type with a plastic shaft, and the push-button must be fitted recessed, so that none of its metal parts protrude from the enclosure.

All equipment connected to K_2 must be powered from a separate supply, battery or adapter.

The operation of the monitor is simple to verify by plugging it into a mains socket and switching a nearby fluorescent tube on and off a few times. Set to the most sensitive range (50 V), the monitor is nearly always triggered if the mains outlet is on the same line as, and within 10 m from, the tube lighting. The number of 'hits' will be found to decrease as the sensitivity of the monitor is lowered, and the distance to the tube is increased. ■

blocked by the rectifier, and they are too fast to be 'followed' by C_1. The result is that each and every spike or dip on the mains voltage appears across R_t. Dips, however, are ignored by the detector circuit.

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Figure 2 shows the circuit diagram of the power line monitor. The mains voltage is rectified by a bridge circuit composed of four diodes Type 1N4007. This diode is used because of its peak reverse voltage specification of 1,500 V. The value of R_9 is a compromise between acceptable dissipation and sufficient loading of C_1. The high-pass filter is formed by C_1 and R_1-R_8. The minimum working voltage of C_1 must be 630 VDC since the device has on it the rectified voltage of about 340 V. The resistor ladder network, R_1-R_8, has only the spikes across it.

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- the inputs are protected up to 2.5 kV typical;
- the input capacitance is low at 3.5 pF typical;
- the minimum width of the trigger pulse is 14 ns;
- the trigger level is accurately defined at 1.3 V, which enables a simple voltage divider to be used.

Note, however, that the actual minimum trigger pulse width is determined by the input attenuator and the stray capacitance of the input protection diodes, D_9-D_{10}, and the trigger input of IC_{1b}. This R-C combination forms a low-pass filter that causes spikes to be detected only if they are longer than 50 µs.

Monostable multivibrator (MMV) IC_{1b} is triggered when the attenuated spike voltage exceeds the trigger threshold set with S_1. On triggering, outputs Q and $\overline{Q}$ supply a 20-ms pulse. The pulse at the Q output is fed to IC_{1a}, which lengthens it to about 1 second. During this time, LED D_{11} and buzzer Bz_1 signal the occurrence of a

OPERATION AND CONTROLS

Range switch (S_1): set to expected spike level. Spikes exceeding set level are detected and indicated.

Test switch (S_2): press to test trigger function (manual trigger)

LED (D_5): on/off indicator

LED D_{11} and buzzer Bz_1: spike indicators

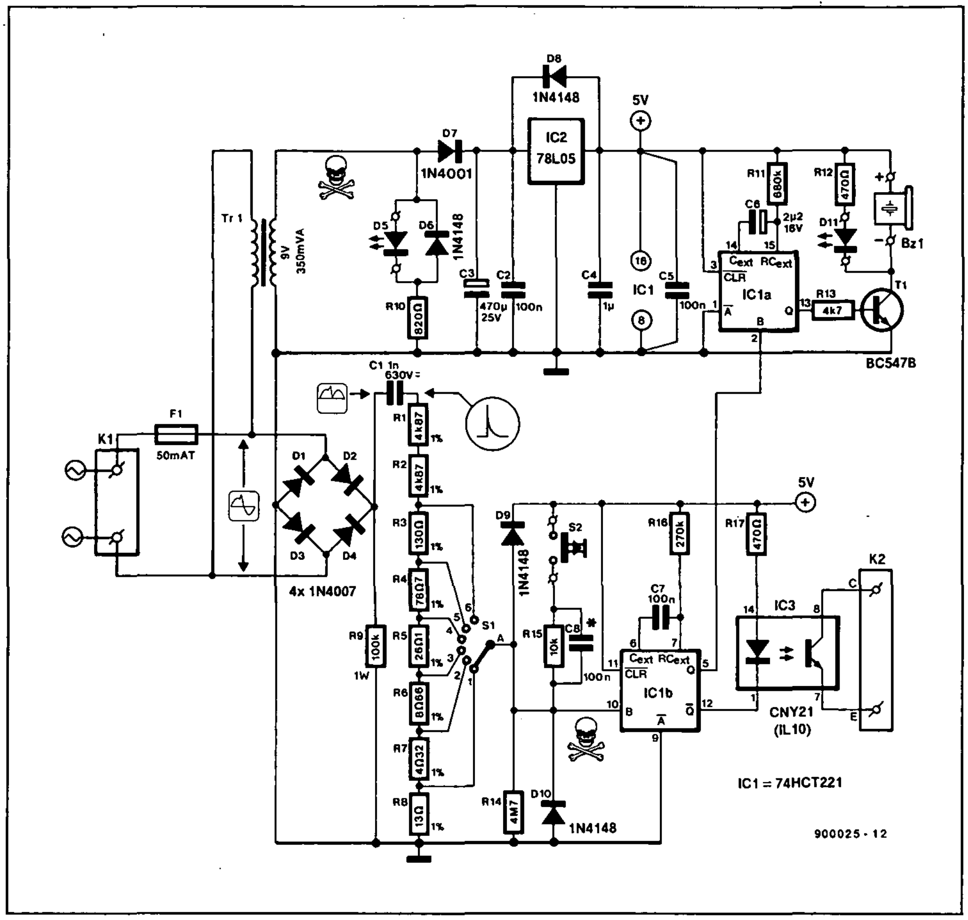


Fig. 2. Circuit diagram of the power line monitor.

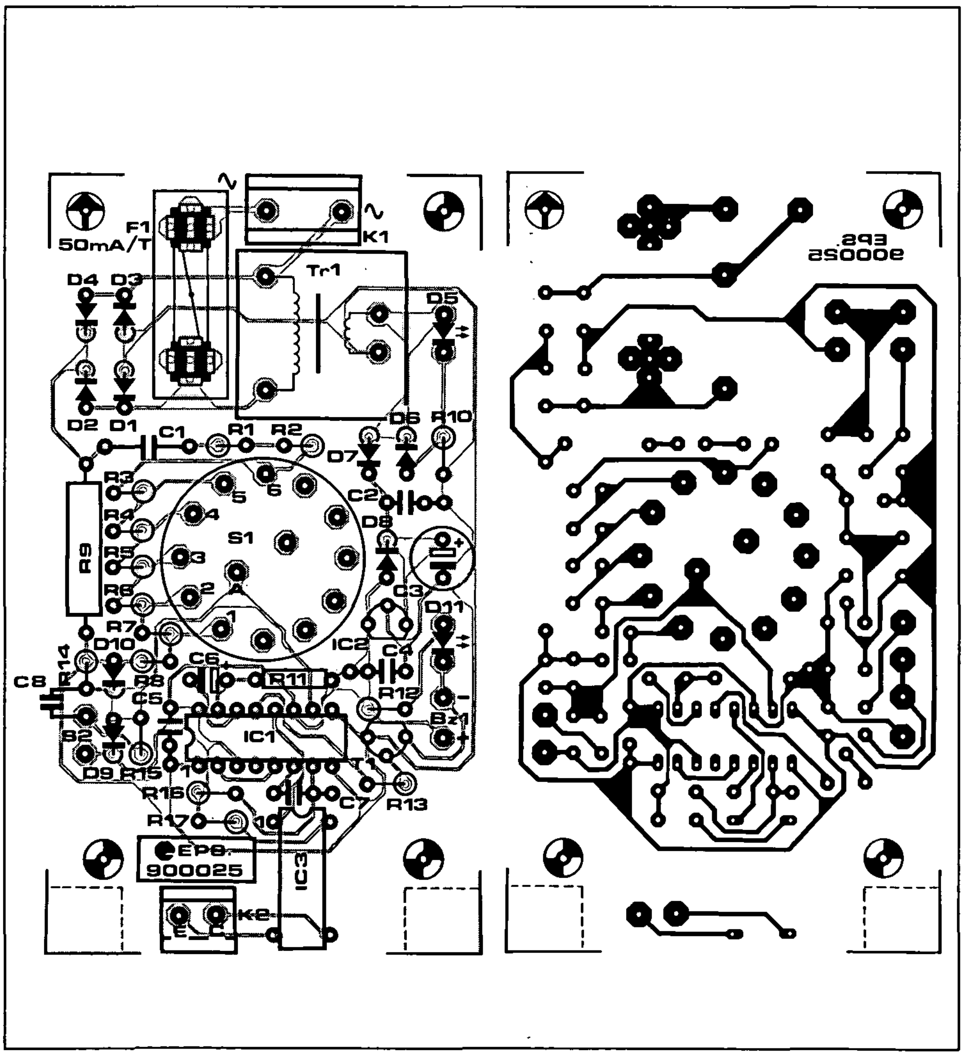


Fig. 3. Printed-circuit board overlay and track lay-out (reflected).

SURGE SUPPRESSOR

J. Ruffell

It is an annoying but generally accepted fact that much mains-operated equipment produces surges and other interference on the mains. But we do not have to put up with clicking noises from AF equipment as the refrigerator switches on, or a computer that stops working when the lights are switched on. All that is needed to prevent these irritating effects is a good-quality mains filter.

Ideally, any mains outlet supplies an alternating voltage of a root-mean-square (rms) value and a frequency specified by the national (or local) electricity supplier (in the larger part of the UK, these values are 240 V_{rms} and 50 Hz respectively). In practice, however, this is hardly ever so. In not a few cases, the mains voltage is occasionally corrupted by high-frequency signals, data-bursts, brief fluctuations, surges and dips.

Although mains signalling is a well-defined area*, some types of mains intercom operating at carrier frequencies of 100 kHz and up are notorious sources of interference. Pulse-like interference often emanates from dimmer circuits, switch-mode power supplies in computers and defective or poorly decoupled household equipment like coffee machines and refrigerators.

In some countries, the electricity suppliers themselves use the mains lines to convey control information for normal/reduced rate switching of domestic power consumption meters.

To avoid problems with any equipment powered from the mains, a mains filter as the one described here must work in both directions, which means that both mains-borne interference and interference generated by the equipment must be suppressed. The filter proposed here is suitable for use with 220–240 V mains systems operating at 50 Hz.

Design considerations

The mains filter is basically a passive low-pass with a roll-off frequency of 50 Hz. Its likeness to a low-pass filter for audio applications is only superficial however since the high operating voltage and the associated considerations as regards safety govern the use of special components. In many countries, standards have been set up that define the maximum capacitor values used in the filter, often depending on whether mains-powered equipment is wall- or floor-mounted, or portable. These capacitor values are a carefully established compromise between acceptable switch-on and switch-off currents on the one hand, and the risk of electrical shock in the case of defective or improperly connected earthing on the other.

Capacitors alone can not secure the required slope steepness of the filter. The attenuation outside the pass-band is improved considerably by using one or more chokes. These come in at least three versions. In general, the choke with the highest inductance is the most effective. However, if reactive loads are powered, the voltage drop across the choke rises with inductance. In practice, this means that the filter has to be geared accurately to the load and the nature of the anticipated interference.

The simplest version is the saturation choke. When the mains is switched on, this type of inductor possesses a high inductance, which rapidly becomes smaller as the current causes the ferrite-iron core to become saturated. The interference suppression grade is nearly always specified for symmetrical (balanced) interference, that is, interference that exists between the live (L) and neutral (N) line.

The multiple-winding current-compensated toroid choke is more effective but also more expensive than the saturation type. Strong capacitive coupling between the circuit and the enclosure causes an asymmetrical current (between L/N and E) to flow into the equipment through the earth wire, and half of it back into the mains through the live or neutral line. The partial interference current causes the choke, of which the windings are inserted in the phase or neutral line, to be damped so that the magnetic fields generated in the windings cancel one another. The inductance of both chokes is small for the load current and therefore introduces a small voltage drop only.

The bar-type choke is best used for loads over 100 A that produce mainly symmetrical interference (between live and neutral). In contrast to the saturation choke, the inductance of a bar-type choke remains constant.

Practical circuit

The circuit diagram of the mains filter is given in Fig. 1. The mains voltage is applied via connector K_1. Components C_1 and R_2 form a potential divider for the on/off indicator, D_1. Capacitor C_1 dis-

* Mains signaling in the UK is subject to the provisions of British Standard BS6839. Further information on the subject may be obtained from BIMSA (BEAMA Interactive and Mains Systems Association), Leicester House, 8 Leicester Street, LONDON WC2H 7BN, Telephone: (01-437) 0678.

charges via resistor R_1 when the filter is disconnected from the mains. Diode D_2 is connected across D_1 to keep the reverse voltage across the LED within safe limits. Voltage peaks exceeding 250 V are eliminated by varistor VDR_1.

Capacitors C_2 and C_3 must be class-X2 types. Similarly, C_4 and C_5 must be class-Y types. These type codes indicate an a.c. working voltage of 250 V and apply to metallized polyester or polypropylene capacitors with good self-healing properties should arcing occur in the dielectric material. X2-class capacitors may not be used in positions where their failure would expose anybody to electric shock. Consequently, these capacitors are connected between the live and neutral lines to ensure that failure can only cause a blown fuse (in the case of a short-circuit) or reduced filter operation (in the case of an open-circuit). Both effects are annoying but not dangerous.

The requirements of the Y-type capacitors, C_4 and C_5, are more stringent (see B.S. 6201, part 3, and IEC 161). Like C_2 and

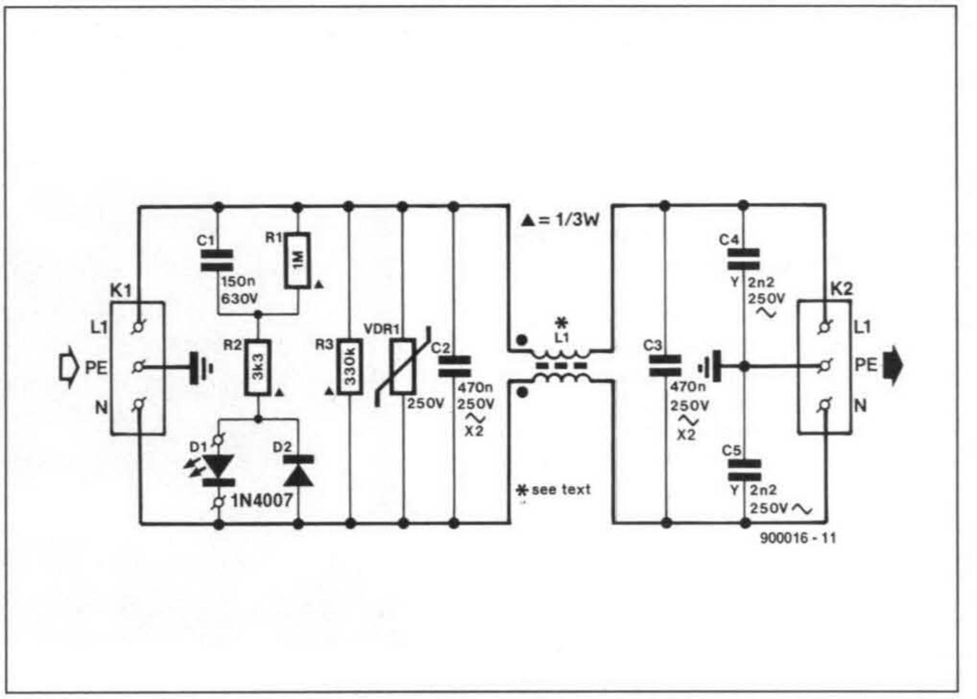


Fig. 1. Circuit diagram of the surge suppressor.

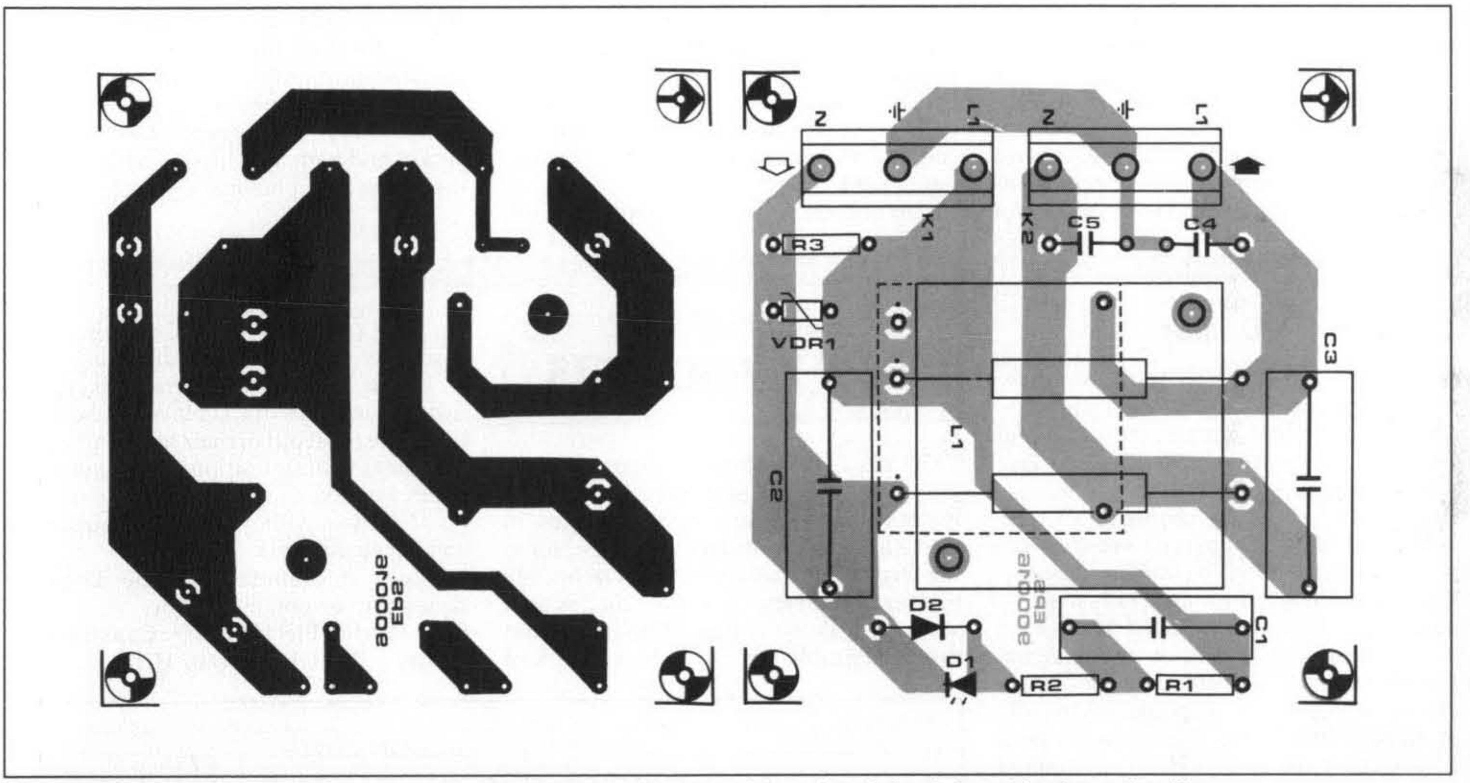


Fig. 2. Track lay-out (mirror image) and component mounting plan of the printed-circuit board for the mains filter.

COMPONENTS LIST

Resistors:
R_1 = 1M0 0.33 W
R_2 = 3k3 0.33 W
R_3 = 330k 0.33 W
VDR_1 = S10K250 [1]

Capacitors:
C_1 = 150n; 630 VDC
C_2;C_3 = 470n; 250 VAC class-X2 [2]
C_4;C_5 = 2n2; 250 VAC class-Y [3]

Semiconductors:
D_1 = LED 5 mm red
D_2 = 1N4007

Miscellaneous:
L_1 = choke 2×10 mH Type RD62-3 or 2×4 mH type RD 62-6 [4].
F_1 = fuse 2.5 A slow (for RD62-3) or 5 A slow (for RD62-6).
K_1;K_2 = 3-way PCB screw terminal block (pin distance 10 mm).
ABS enclosure 110×110×65 mm.
Panel-mount mains socket with integral fuse-holder.
Panel-mount mains receptacle.
PCB Type 900016 (not available through the Readers Services).

[1] ElectroValue Limited • 28 St Judes Road • Englefield Green • Egham • Surrey TW20 0HB. Telephone: (0784) 33603. Telex: 264475. Fax: (0784) 35216. Northern branch: 680 Burnage Lane • Manchester M19 1NA. Telephone: (061 432) 4945.

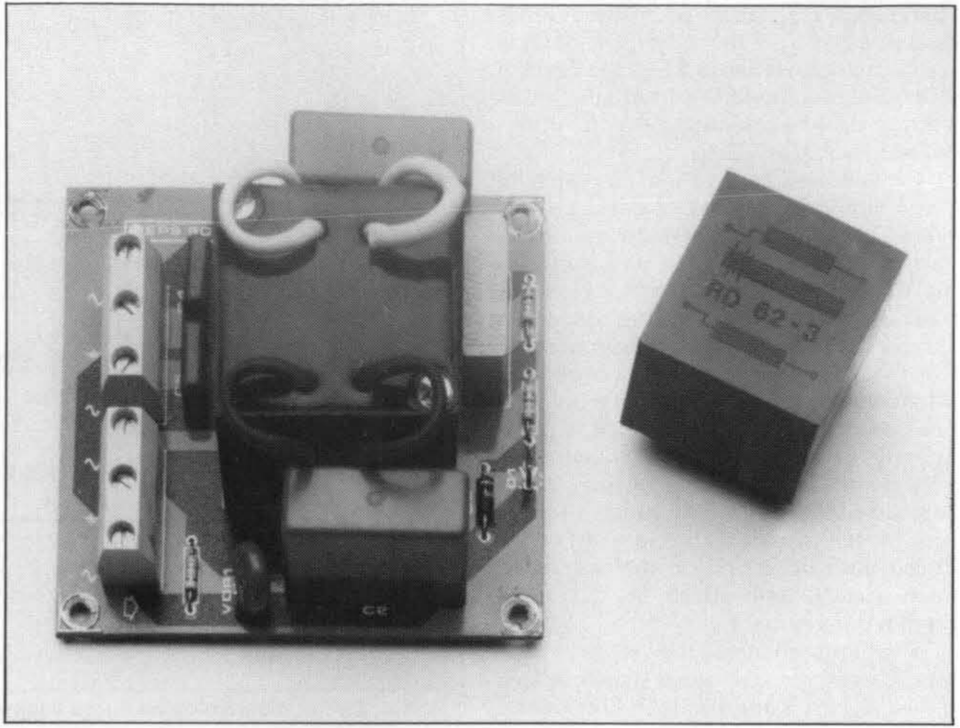
[2] e.g., RS Components stock no. 115-219.
[3] e.g., RS Components stock no. 114-496.

[4] Schaffner UK • Headley Park • Area 10 • Headley Road East • Woodley • READING RG5 4SW. Telephone: (0734) 697179.

C_3, they cause degraded filter operation in the case of open-circuit failure. More importantly, however, a short-circuit in either C_4 or C_5 causes the live (L) or neutral (N) line to be connected to the protective earth line. Hence the following warning:

Never use capacitors of a different type or rating than those indicated.

The inductance in the filter is formed by a current-compensated choke. The printed-circuit board allows two different types from Schaffner to be fitted. These types differ in respect of maximum load current and inductance. The 2x10 mH inductor Type RD62-3 is rated for up to 3 A, and the 2×4 mH Type RD62-6 for up to 6 A.

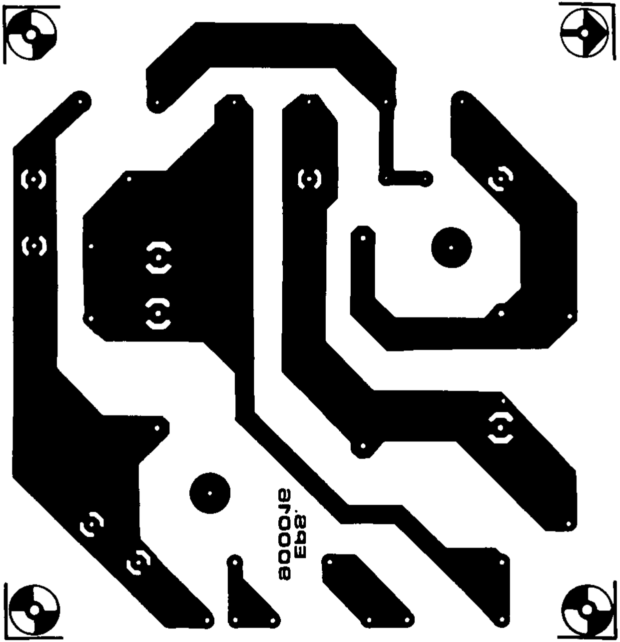


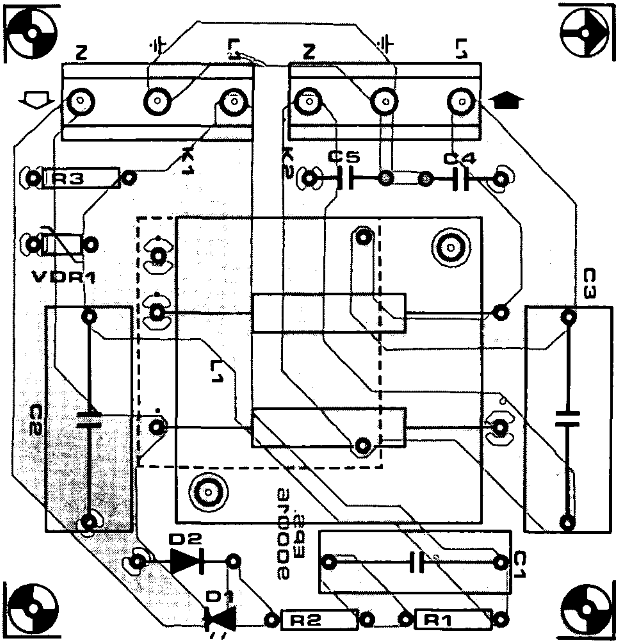
Construction

For reasons of safety, the mains filter must not be constructed on any other board than that shown in Fig. 2. Construction is straightforward with the possible exception of L_1, of which the mounting depends on the type used. The larger and more expensive 6-A inductor is fitted upside-down on the PCB. The underside of the choke has four colour-marked wires. The two dark-coloured wires are the input connections (at the side of C_2 in the circuit diagram). The two light-coloured wires are the output connections (at the side of C_3 in the circuit diagram). The photograph in Fig. 3 shows the RD62-6 on the completed board.

The smaller 3-A inductor Type RD62-3 is fitted in the normal manner with the connections inserted direct into the relevant PCB holes.

Do not test the mains filter before it is fitted into the relevant equipment, or —if it is to be used for various appliances— into a separate ABS enclosure without any metal part. The prototype shown in the introductory photograph has a mains socket and a mains plug for panel mounting as used on personal computers. ■





Z
L
Z
L
K1
K2
C5
C4
R3
VDR1
C3
L1
C2
D2
D1
R2
R1
C1

AUDIO/VIDEO MODULATOR

Many inexpensive or older TV sets lack a SCART or other composite video input, and can only be connected to a video recorder or other equipment via an RF modulator. The modulator described here —a design by ELV— operates at a UHF TV channel between 30 and 40. Use is made of a single-chip RF modulator that couples low cost to excellent sound and picture quality.

TV sets that lack an external video input are still manufactured and sold in large numbers. In many cases, these sets are relatively inexpensive types manufactured in Far Eastern countries. Unfortunately, upgrading such a TV set with an external video input is not possible in general because the chassis is at mains potential. Not a few owners of a low-cost TV set are therefore faced with connection problems if the set is to function as a display for, say, a computer that has a composite video output but lacks an RF modulator.

The present modulator covers the frequency range from 545 MHz to 625 MHz, which corresponds roughly to UHF TV channels 30 to 40. The circuit consists of two parts:

a modulated RF oscillator in a small metal box;

a motherboard on to which the RF oscillator, the SCART socket and the supply voltage regulator are fitted.

The motherboard and the RF oscillator form a compact unit fitted in an ELV Microline enclosure as shown on the above photograph. The modulator is powered by an external mains adapter with an output voltage of 12–15 V at about 250 mA.

Since the RF oscillator is a separate module in the modulator, it may be used without the motherboard to upgrade existing video equipment with a TV output.

MAIN SPECIFICATIONS

- High output level: approx. 100 mV (80 dBμV)
- Good frequency stability
- Low spurious radiation
- Audio-video input with SCART socket
- Adjustable sound subcarrier frequency
- Suitable for upgrading existing equipment

The circuit

The circuit diagram of the RF oscillator with modulation input is given in Fig. 1. The heart of the circuit is formed by IC_1, a Type TDA5660P single-chip multi-standard VHF/UHF audio/video modulator from Siemens.

The amplitude of the sound signal applied to pin 6 of the SCART socket, Bu_1, is set with P_1. Note that the SCART socket and the preset are not contained in the RF-tight metal enclosure. The sound signal is capacitively fed to the FM (frequency-modulation) sound input of the TDA5660P via C_1-C_2-R_2. Components R_2-C_2-R_3 form a pre-emphasis network. The frequency-modulated sound subcarrier is added to the vision signal by the RF mixer in the TDA5660P.

The sound subcarrier frequency (UK: +6.0 MHz) is set by a parallel tuned circuit, L_1-C_{14}. The vision-to-sound carrier ratio of 12.5 dB is ensured by R_9. Capacitor C_{22} connects the AM (amplitude-modulation) sound input of the TDA5660P to ground for alternating voltages.

The CVBS (chroma-video-blanking-sync) signal taken from pin 20 of the SCART socket is terminated into R_{11} and capacitively fed to video input pin 10 of the modulator chip via C_{18}. A clamping circuit at this input establishes a fixed synchronization level, while an automatic gain control circuit that acts on the peak white values compensates amplitude changes of up to 6 dB. Both the clamping circuit and the gain control circuit are internal to the TDA5660P. Capacitor C_{17} filters the current pulses produced by the peak white detector, and its value determines the time constant of the gain control.

The modulation index of the AM vision signal is set by the potential at pin 12 of the TDA5660P. If no resistor is connected to this pin, the modulation index is 0.8 (80%) for negative video modulation. Note that pins 12 and 2 (reference voltage) are decoupled to ground to prevent interference.

The symmetrical oscillator on board the TDA5660P is bonded out to pins 3-7. The external tuned circuit is formed by inductor L_3 in combination with capacitors C_4 and C_{10}, and variable capacitance diode D_1. Capacitors C_5 and C_{11} prevent the direct voltages at pins 3 and 11 being short-circuited via L_3. The oscillator has a separate ground connection bonded out to pin 5.

The anode of varicap D_1 is grounded for direct voltages by R_4. The oscillator frequency is adjusted with the aid of a tuning voltage supplied by preset R_6 and applied to D_1 via R_5. Capacitors C_9 and C_{12} decouple the RF voltage generated by the oscillator.

The modulated RF signal (AM vision and FM sound) is taken from the outputs of the balanced mixer in the TDA5660P via pins 13 and 15. The output impedance of 300 Ω balanced is transformed down to 75 Ω unbalanced by L_2, a Guanella transformer, perhaps better known as a balun. Capacitor C_{16}, finally, feeds the modulated UHF signal to the RF output socket via terminal ST_6.

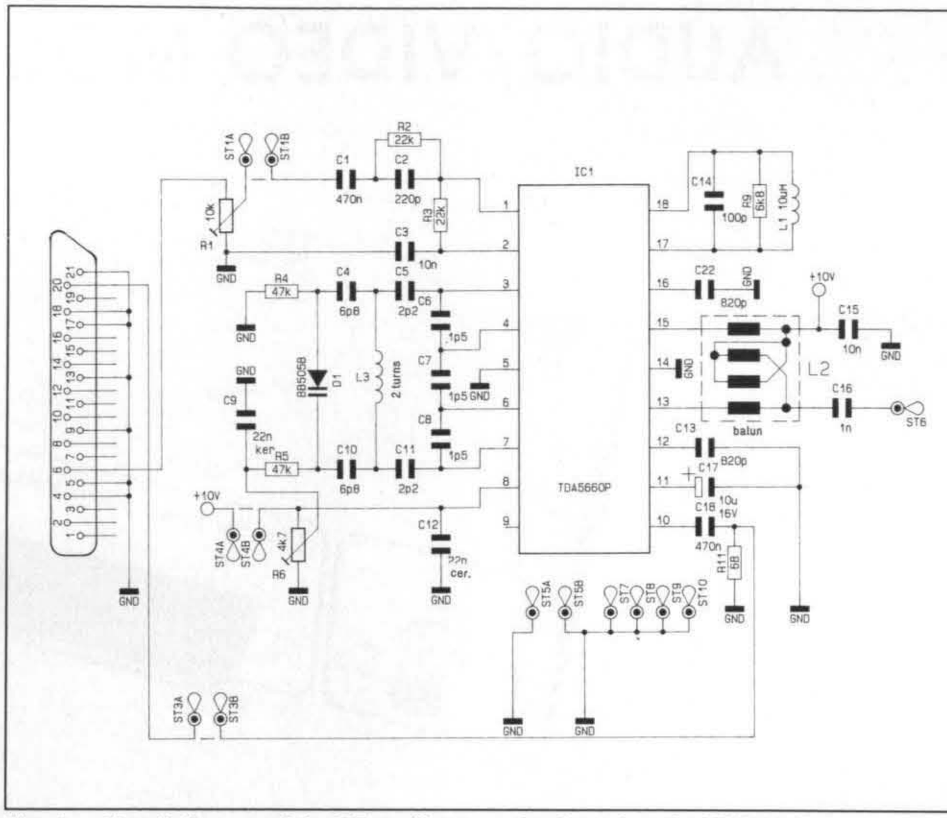


Fig. 1. Circuit diagram of the RF oscillator section based on the TDA5660P.

The modulated RF oscillator is powered by a regulated voltage of 10 V. A 12-V supply may also be used in case the oscillator is incorporated into existing equipment. The output voltage must, however, be regulated.

The motherboard has on it the RF oscillator module, the SCART socket, Bu_1, the sound level control, R_1, and the 10-V regulated power supply. The circuit diagram of the latter unit is shown in Fig. 3. The unregulated voltage applied to socket Bu_1 may lie between 14 V and 17 V. The current consumption of the modulator is less than 50 mA, so that a small mains adapter may be used.

The power supply itself is a standard design based on a three-pin fixed voltage regulator Type 7810 (IC_2). LED D_3 functions as an on/off indicator. The minimum and maximum voltage that may be applied to Bu_1 is 12.7 V and 25 V respectively.

Construction

The main point to note about the construction of the modulator is that the RF oscillator must be thoroughly screened to ensure mechanical as well as electrical stability and at the same time prevent spurious radiation of the UHF signal.

Start the construction by populating the oscillator board: fit and solder the two wire links, the six resistors and the varicap. Next, fit the capacitors, making sure that the ceramic types are pushed as far as possible towards the PCB surface. Fit preset R_6 and inductors L_1 and L_2. Do not fit the balun the wrong way around: the connection that consists of four joined wires goes to C_{15}. Finally, fit the TDA5660. Do not use an IC socket.

Inductor L_3 is made by winding 2 turns of silver-plated wire around a 3-mm drill or pencil. Take the inductor from the former and space its turns evenly by about 2 mm. Insert its terminals into the relevant PCB holes and push it as close as possible to the PCB surface. Solder the terminals at the track side.

Finally, fit four solder terminals at the track side of the board, and one solder terminal (ST_6) at the component side.

Bend the strip of tin-plate screening supplied with the kit at the indicated places to form a box. Join the ends by soldering. Fit the oscillator board into the box and ensure that the track side is about 3 mm above the lower edge of the tin-plate box. Solder the board to the inside of the box at all four sides. Work quickly to prevent overheating, and use a high-power (50-W) solder iron to ensure a smooth and firm connection.

Mount a narrow strip of tin-plate vertically between the two rows of IC pins at the track side of the board as shown in the photograph in Fig. 4. Like the box, this strip is soldered over its entire length.

Insert the panel-mount TV plug into the side panel hole, and secure it by soldering. Use a short length of light-duty wire to connect the centre pin of the plug to terminal ST_6.

Proceed with the population of the motherboard, which contains few parts only. LED D_3 is soldered to terminals ST_{11} and ST_{12}. Four additional solder terminals are fitted to enable the sides of the RF oscillator box to be secured later.

Inspect the two boards for short-circuits and bad solder joints, and correct any errors if necessary. Mount the bottom cover on to the oscillator box, making sure that it does not touch any of the four solder pins which should be about central in the holes provided in the cover. Solder the bottom cover to the sides of the box.

Place the oscillator box on the motherboard and insert the four terminals into their respective holes. Solder them at the track side of the board. Next, solder the four terminals on the motherboard to the sides of the oscillator box.

Adjustment

The adjustment of the modulator is relatively simple and does not require special test equipment.

Connect the modulator to the video source, the TV set and the mains adapter. Tune the TV to a free channel between 30 and 40. Adjust R_1 until the remodulator is tuned to the TV channel. The tuning range of the preset should cover the UHF range between channels 30 and 40. If this is not so, carefully stretch or compress the turns of L_3 until the required range is covered.

Next, adjust the sound channel. Turn

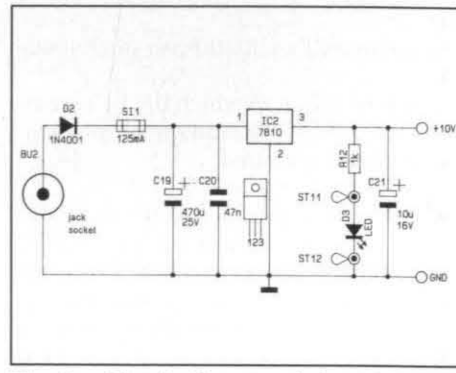


Fig. 2. Circuit diagram of the 10-V regulated power supply.

the core in L_1 until the sound on the TV set is clear and undistorted.

If the modulator works to your satisfaction, mount the top cover on the oscillator box, and secure it by soldering. Next, place the complete assembly into the ABS Microline enclosure. The printed and pre-drilled front-panel supplied with the kit is fitted last by pressing it firmly from one side so that it clicks into the enclosure. ■

COMPONENTS LIST

Resistors:
R_{11} = 68Ω
R_{12} = 1k0
R9 = 6k8
R_2;R_3 = 22k
R_4;R_5 = 47k
R_6 = 5k0 preset V
R_1 = 10k preset V

Capacitors:
C_6;C_7;C_8 = 1p5
C_5;C_{11} = 2p2
C_4;C_{10} = 6p8
C_{14} = 100p
C_2 = 220p
C_{13};C_{22} = 820p
C_{16} = 1n0
C_3;C_{15} = 10n
C_9;C_{12} = 22n; ceramic
C_{20} = 47n
C_1;C_{18} = 470n
C17;C_{21} = 10µ; 16 V
C_{19} = 470µ; 25 V

Semiconductors:
IC_1 = TDA5660P
IC_2 = 7810
D_1 = BB505B
D_2 = 1N4001
D_3 = LED; 3 mm; red

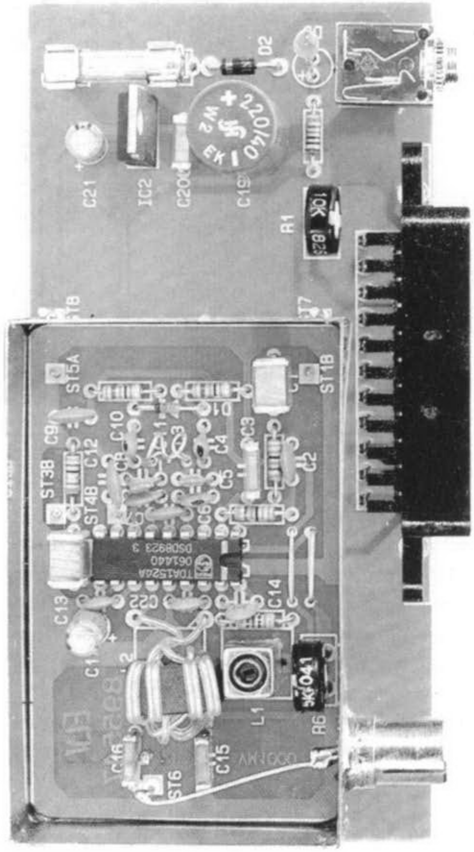
Miscellaneous:
L_1 = 10µH.
L_2 = balun.
Bu_1 = SCART socket for PCB mounting.
Bu_2 = jack socket for PCB mounting.
Si_1 = fuse; 125 mA.
Qty. 1: tin-plate box (complete).
Qty. 1: TV coax plug.
Qty. 1: PCB-mount fuse holder.
Qty. 11: solder pin.
85 mm light-duty wire.

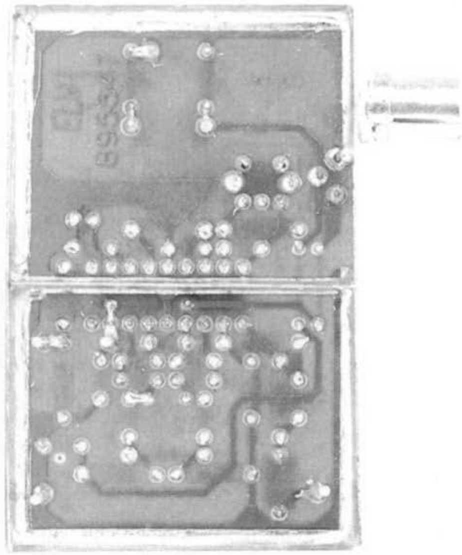
A complete kit of parts for the audio/video modulator is available from the designers' exclusive world-wide distributors (regrettably not in the USA and Canada):

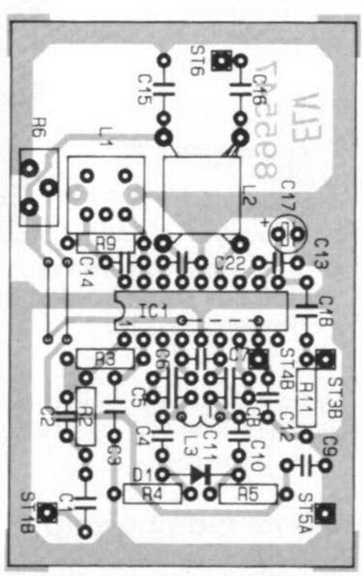
ELV France
B.P. 40
F-57480 Sierck-les-Bains
FRANCE
Telephone: +33 82837213
Fax: +33 82838180

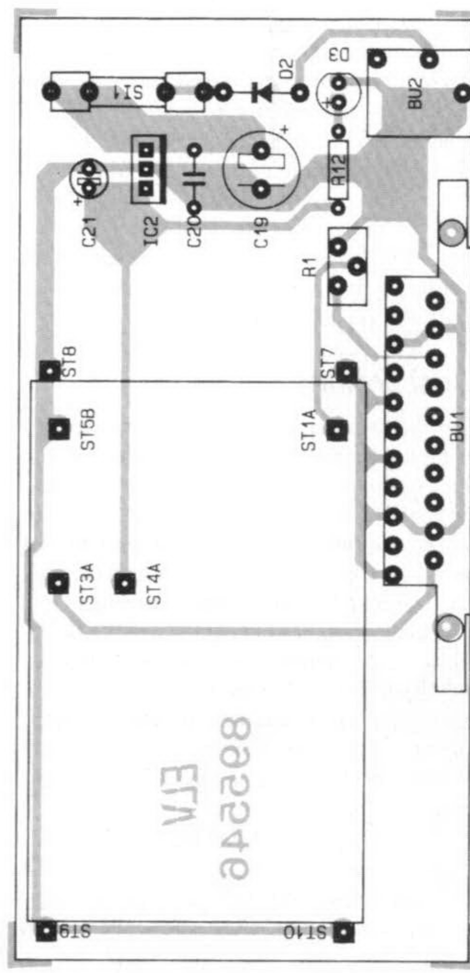
Also see ELV France's advertisement elsewhere in this issue.

Below: completed RF oscillator module seen from the PCB track side. Note the screen fitted vertically in between the pin rows of the dual-in-line integrated circuit. This screen is essential to keep spurious radiation of the modulator to a minimum.
Right: top view of the completed RF modulator assembly. The RF oscillator box is mounted on to the main board. Note that the top cover has been removed for an internal view of the oscillator.









Above: component mounting plan of the RF oscillator board.
Right: component mounting plan of the motherboard.

SCIENCE & TECHNOLOGY

RESEARCH AND DEVELOPMENT: KEYNOTE OF CLUB LIFE AT HARWELL

by H. Cole, CEng, MIERE, Senior scientist at Harwell Laboratory

Harwell Laboratory, situated about 50 miles to the west of London, is the largest United Kingdom Atomic Energy Authority (UKAEA) research establishment. It has an annual turnover in the region of £140 million and employs 4250 people. The laboratory was set up in 1946 to carry out research into all aspects of atomic energy and furnish the scientific and technical information needed for Britain to embark on a nuclear power programme. The result of this early work culminated in the commissioning in 1956 of Britain's first nuclear power station: a 200 MW plant that is still feeding power into the national grid.

Today there are 17 nuclear power stations operating in Britain and one (a pressurized water reactor—PWR) is under construction. Together, these satisfy about 20% of the country's electricity demand.

Since 1965, the laboratory has undertaken an increasing amount of work that is unconnected with nuclear research and, although there is still a substantial nuclear programme, this now accounts for little more than half of the financial turnover.

The non-nuclear work involves liaison with a wide sector of industry and commerce and ranges in scope from the neutron radiographic examination of jet engine turbine blades to the ultrasonic inspection of hundreds of miles of rail track and consumer gas distribution pipelines. Clients range from small private companies to giant multinationals; contract values can be as little as hundreds of pounds or as great as several millions.

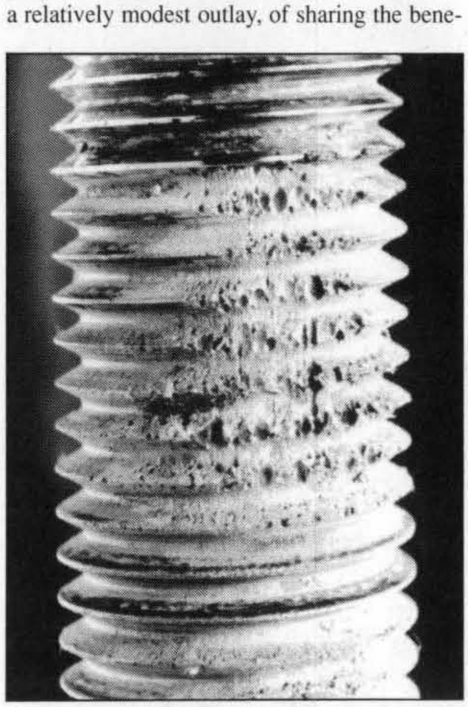
Cost sharing

The ever increasing complexity of present day technologies and the need for innovation and the development of new materials and processes have demanded facilities that are often beyond the financial and material resources of all but very large organizations; hence the need for a research establishment like Harwell. Clients may visit the laboratory and hire the facilities and scientific back-up for as long as they wish without having to embark upon expensive in-house alternatives. They can also join one of the many cost-sharing research and development clubs that are operated by the laboratory.

Harwell's first club, the Heat Transfer and Fluid Flow Service (HTFS) was set up in 1968 and is operated jointly with the National Engineering Laboratory and, since 1983, with Atomic Energy of Canada Limited. Other clubs were added during the 1970s but growth in their numbers began in earnest during the 1980s as industry began to emerge from the international recession.

Harwell now operates a total of 30 clubs covering a wide spectrum of industrial technology and the number is growing by about two every year.

Club-funded research and development programmes give members the advantage, for a relatively modest outlay, of sharing the benefits accruing from a particular project while maintaining confidentiality with regard to potential (non-club) competitors.



An example of a failed high strength marine bolt examined by the Offshore Bolting Materials Club of Harwell Laboratory.

Multinational membership

There are essentially two types of Harwell club activity. The first is basic research with no obviously exploitable end product in mind but which may provide valuable background information for subsequent commercially viable development programmes. Examples of this include materials evaluation programmes for solid-state gas sensors and the development of techniques for studying combustion behaviour in advanced petrol engines.

The second kind of club activity is the development of technology to support a company's activities on a wider scale than would be tackled in-house. It is this area of work that calls upon the special skills and facilities of Harwell. Examples include the formulation of offshore inspection techniques and associated instrumentation, and of an inspection system for composite materials.

The detailed structure and operation of the various clubs varies considerably to suit their particular activities. Some larger clubs may have nearly 200 members, whereas the smaller, more specialized, ones may have about ten. The work undertaken by a club may be confined to a particular type of industry, such as offshore inspection, whereas other more broadly based clubs may span a wide range of industries. The Composite Metal Jointing Club, for instance, has a membership drawn from the aerospace, automobile, adhesive and composites manufacturing industries.

Clubs with a multinational membership attract financial support from the European Community and cover research and development that is advantageous to member states. Typical of the many internationally funded ones is the Residual Fuel Oils Club, which studies the combustion characteristics of low-quality residual fuel oils. Membership fees generally range from about £5,000 to £15,000 per year but can be much higher. Some club fees are dependent on company turnover and are generally larger for overseas organizations. For small British companies, the fees are usually in the region of £3,000 a year.

Guided by members

Most club projects are of limited duration and are organized into phases, the results from one phase determining the direction and extent of the next. Some clubs, like the Diesel Engine Working Party, have successfully completed their programmes and ceased operation. Others, such as HTFS, have rolling programmes that are regularly redirected along lines that reflect the current priorities of their members.

For many clubs, support funding from the British Government or from the European Community often approximates to that of the member's contribution. For some clubs, however, less government funding may be forthcoming and be limited to a simple membership contribution fee. This applies in the case of the Offshore Inspection Service Club whose only form of government funding is a single membership fee.

In spite of these differences in funding and composition, one strong common feature among the Harwell clubs is that the work undertaken is guided by the members and reflects their priorities, providing a firm base for the subsequent transfer of the resulting technology.

The Biotechnical Separations (BIOSEP) Club provides consultancy, design and reports and carries out basic and applied research on all aspects of downstream processing for the biotechnology industry. Membership is drawn from chemical, pharmaceutical and food processing companies, and others with specialist medical and biotechnology interests.

Another club, Composite Metal Jointing, provides design criteria and design tools and data required for load-carrying adhesive joints between polymer-based composites and metals. The membership includes European automotive and component manufacturers, aerospace companies and adhesive and component suppliers.

World-wide membership

Heat Transfer and Fluid Flow Service (HFTS), the oldest Harwell club, has over 185 members. Collaborators are the National Engineering Laboratory and Atomic Energy of Canada. It provides computer programs, design reports, literature digests, consultancy and access to a large international research and development programme on heat transfer and fluid flow. The substantial world-wide membership includes large chemical and petrochemical companies, process plant contractors and small heat exchanger manufacturers.

The Fouling Forum has over 200 members and works in collaboration with the National Engineering Laboratory. It provides a forum for the interchange of ideas and for technology transfer on the subject of fouling of heat exchange services in a wide range of process plant. Membership of this low-cost information exchange club includes all HFTS members and is also open to other subscribers.

The Metal Matrix Composites Club is concerned with research and development into the properties of, and processing methods for, aluminium alloys reinforced with ceramic and other fibres as well as processing routes for specific components. Membership covers several industries and includes aerospace, automobile and component manufacturers and materials suppliers.

Metals and engines

The Midas Club provides a service for the minerals exploration production and processing industries. It develops new or improved analytical methods for interpreting data from neutron and gamma ray-based interrogation probes as used by the oil, gas, coal and metalliferous minerals industries. The members include major oil companies and their contractors plus a number of coal mining companies and their customers.

Offshore Inspection Research and Development Service produces new or improved inspection techniques for offshore structures. The current programme includes work on ultrasonic time-of-flight and eddy current inspection methods and a project on the detection of tight cracks. The membership is drawn from the major offshore operating and inspection companies.

Offshore Bolting Materials is a small club operated in collaboration with Wimpey Laboratories. It develops improved bolts and bolting materials for use on offshore structures. Its members come from the major oil companies and safety authorities.

The Petrol Engine Working Party applies the Harwell-developed laser-Doppler anemometry and CARS (coherent anti-Stokes Raman spectroscopy) techniques and associated instrumentation to studies of air flow and combustion within operating internal combustion petrol engines. Its members are drawn from engine and component manufacturers and a fuel supply company.

Fuel efficiency

Supported by Britain's Department of Trade and Industry and the European Community, the Plasma Etching Club undertakes collaborative programmes for devising techniques for the dry processing of very large-scale integrated circuitry. The work involves the formulation of silicon-based devices and different aspects of etchant chemistry. The members of this club are suppliers of high-purity chemicals and gases and of specialized processing equipment.

Positron annihilation is a non-destructive testing (NDT) technique developed at the National NDT Centre at Harwell. It relies on the emission of positrons (positively charged electrons) from a small radioactive source and the injection of these particles into the object being examined. The positrons, on entering the object, are quickly annihilated by the more numerous negatively charged electroncs and give rise to a pair of gamma rays, each of 0.51 MeV kinetic energy and travelling in opposite directions, for each annihilation event.

The detection of these gamma rays from different directions can indicate the presence of defects in the object being examined, show the onset of fatigue in metals and alloys, or enable the moisture content of resin composites to be determined.

The Positron Annihilation Club investigates the application of this novel technique and its members are drawn mostly from the aerospace industry.

The Residual Fuel Oils Consortium studies the application of laser-based instruments and associated analytical facilities to the combustion characteristics of low-quality residual fuels—such as those used in marine and industrial type engines—to see if they can be burned more efficiently. This is an international consortium involving medium-speed diesel engine manufacturers, a component manufacturer, an oil company and representatives of the shipping industry.

Improving batteries

Separation Process Service (SPS) is a collaborative club operated with the government's Warren Spring Laboratory of Stevenage. It provides reports, consultancy and access to a large research and development programme in five separation process areas: solids drying; gas cleaning; solid-liquid and liquid-separation; and crystallization. Membership covers a wide spectrum of process plant users, contractors and manufacturers.

The Solid State Battery Club carries out research into solid-state rechargeable lithium batteries with the aim of developing the technology required for safe, rugged, light-weight versions suitable for products ranging from power tools and portable consumer products to vehicular traction. The wide-ranging membership represents battery manufacturers, companies with facilities and expertise in the methods likely to be required in battery construction, and potential users of the final product.

Eliminating microchip errors

A new collaborative research project aimed at improving the quality, reliability and performance of semiconductor devices, the Soft Errors Club, was launched recently by Harwell's Micro-electronic Materials Centre.

The membership brings together leading United Kingdom semiconductor manufacturers, users, materials suppliers and scientists with the objective of dramatical reducing the problem known as 'soft errors' in micro-electronic circuits.

Soft errors, more properly called single-event upsets, are caused by alpha particles emitted by naturally occurring radioactive impurities in the materials used to make integrated circuits. The alpha particles carry sufficient electrical charge to alter the contents of memory cells, thereby causing computational errors. The more closely packed the memory cell, the greater is the risk of single-event upsets.

The research programme will extend the technique developed at Harwell, known as fission track autoradiography (FTA). This makes use of optical microscopy to count the number of fission tracks that have occurred in a thin polyamide film coating on a semiconductor specimen that has been irradiated by neutrons derived from a nuclear reactor. This technique alone is capable of detecting the presence of uranium impurity atoms at concentrations as low as two parts per million.

The Soft Errors Club is essentially a two-year programme and has the financial support of the British companies MEDL, INMOS, Anamartic and Britain's Department of Trade and Industry. The club remains open to United Kingdom organizations and overseas companies that have a significant manufacturing presence in Britain. ■

THE DIGITAL MODEL TRAIN

PART 12 – ADDRESS DISPLAY

by T. Wigmore

The address display is a small extension unit that is used in conjunction with the mother board. It indicates to what locomotive address a given controller is set and whether a given locomotive controller is active.

The address display, which may be fitted to each and every locomotive controller, improves the ease of operation of the system. It is not strictly essential, but will be found very useful with concentrated multi-train operation.

If addresses in the locomotive controllers have been set via the RS232 interface, that is, not by hardware, it is convenient if the address setting is displayed to indicate that it has been set correctly.

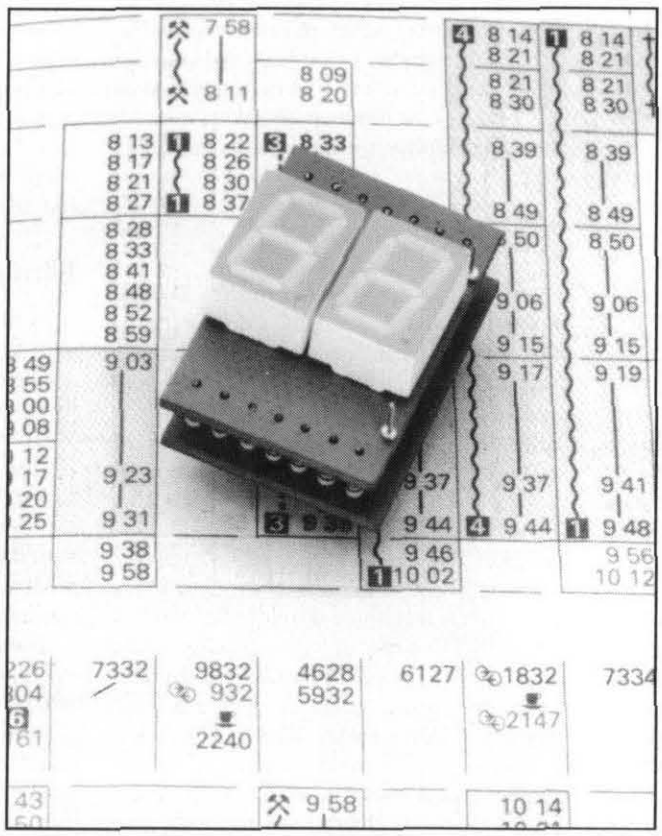
Furthermore, the address display indicates whether a given locomotive controller is active. When a controller is taken out of action or when the control of the relevant locomotive is taken over by the serial interface, the corresponding address display is quenched, except in one condition. When the system is in the stop mode and a locomotive address is set via the RS232 interface, the display will indicate that address although the controller is inactive.

Because of this arrangement, addresses may be set in the controllers via the RS232 interface and checked while the system is still in the stop mode. When the system is then actuated, the displays of all non-active controllers will go out.

A controller is not active if:

- it is not connected to the mother board;
- the operating switches are in position "out of action" (high impedance at pins 4 and 5 of the DIN connector);
- a controller with higher priority has been set to the same address;
- the locomotive with the relevant address is given a control instruction via the RS232 inter face.

The last condition needs amplification. Any control instructions to locomotives via the RS232 interface will deactuate the controllers that serve the locomotives with the same address. The control of any locomotive that is operated via the RS232 interface may be reverted to manual by the locomotive enable command <37>. When this instruction is given, the display of the associated controller will light again.



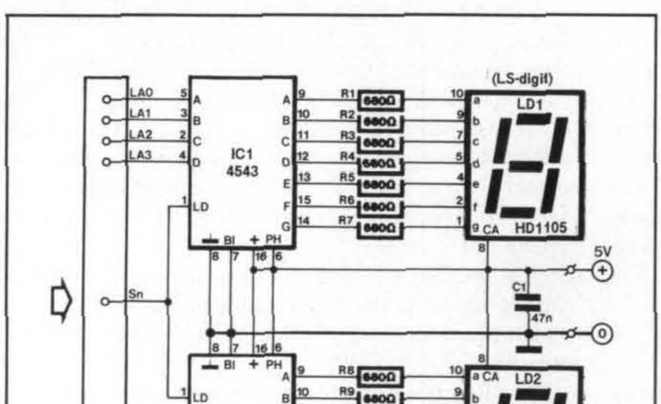


Fig.79. The circuit of the address display is simplicity itself.

Circuit description

As is clear from Fig.79, the circuit of the address display is simplicity itself, because the control is provided by the mother board.

The circuit proper consists of two BCD-to-7-segment decoders with integral register and the displays.

The decoders are connected to the identically-named locomotive address bus on the mother board via lines LA0–LA7 (LA = locomotive address).

Line Sn carries the selection signal that becomes active as soon as a given controller is selected. The selection causes a certain locomotive address set by hardware to be read and then to be written into the registers of the BCD-to-7-segment decoders.

If there is no controller connected, the display is quenched at once by the system writing FFH to it. The display is also quenched if the system signals a controller with higher priority, that is, a higher controller number, which is set to the same address or if the locomotive with the associated address is controlled via the serial interface.

If no address has been set by hardware, the system verifies whether an address for the relevant controller has been given via the RS232 interface. If so, the address that has been converted to BCD format is sent to the display circuit. It is for this reason that the buffer for reading the locomotive address (IC_1 on the mother board) must be a bidirectional type.

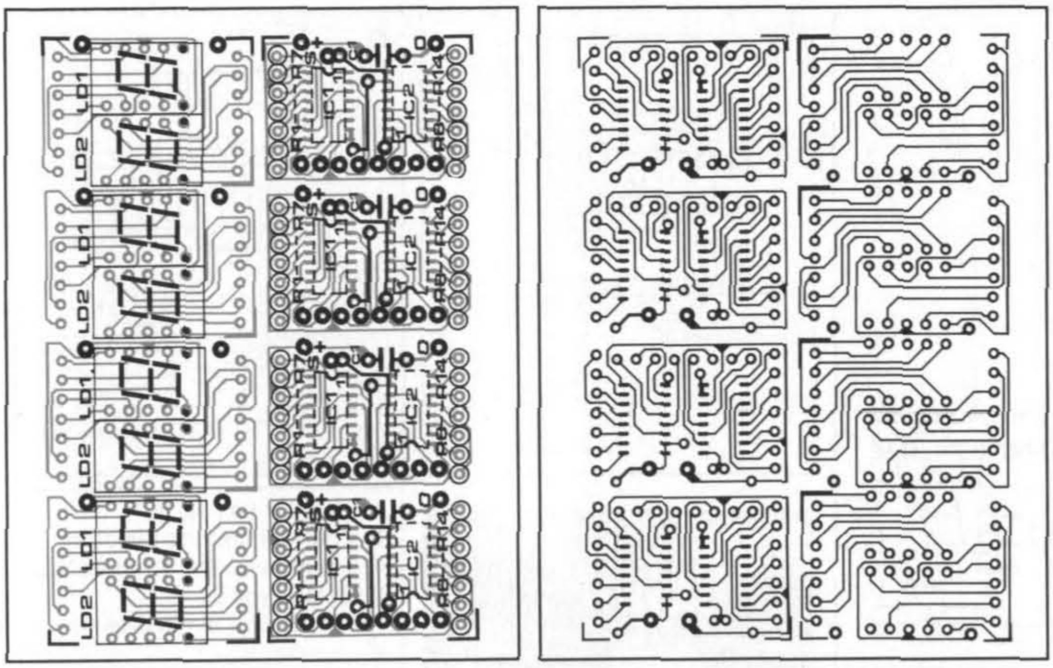


Fig. 80. The printed circuit board is designed for building up to four address display units.

PARTS LIST

R1–R14 = 680R (small types)
C1 = 47 n (preferably SMA type)
IC1, IC2 = 4543 (SMA type)
LD1, LD2 = HD1105 (red)
PCB 87291-9

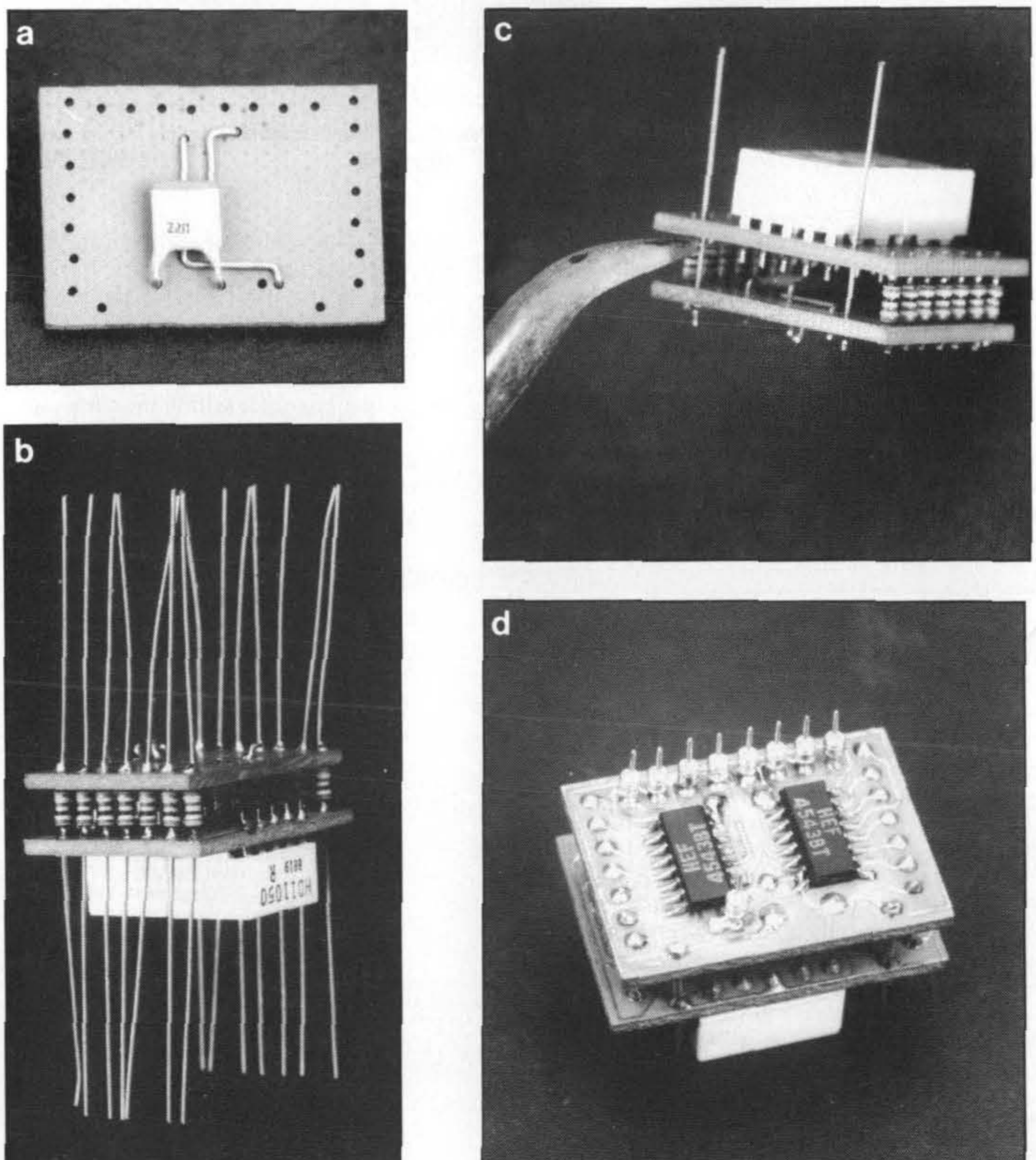


Fig. 81. Construction of the boards as a sandwich: 81a – the decoupling capacitor is laid flat on the board; 81b – through connexions are made with the aid of the resistors; 81c – the power lines are looped through; 81d – the sandwich is ready for connexion to the mother board.

Construction

The construction of the display involves some rather fiddly work, because to keep the unit small, the components should, if at all possible, be very small or of the SMA (surface mount assembly) type. In the case of the ICs, there is no choice: they must be SMA types.

The boards are not wider than the displays to enable a number of units to be mounted side by side (unless only one locomotive controller is used, of course).

Furthermore, the most convenient type of construction is the sandwich type in which the resistsors are used for making the necessary connexions.

The printed-circuit board in Fig. 80 allows up to four display units to be constructed. The mother board can handle up to 16 displays, so that if the maximum is chosen four PCBs are required.

Before the construction proper can be started, the board must be cut (lengthwise) into two identical strips if four adjacent units are wanted or into eight parts if four discrete units are required. The following notes apply to the building of one unit only.

- Some assembly instructions are given in the caption of Fig. 81.
- *Mount both 7-segment displays* on to the top "wafer".
- Fit both right-angle wire links to the non-copper side of the lower "wafer".
- Mount decoupling capacitor C_1 at the copper side of the upper "wafer". If an SMD type proves unobtainable, use a small ceramic type and mount this as shown in Fig. 81a.
- Mount IC_1 and IC_2 at the copper side. Pins 1–8 are located at the bevelled side of the devices. These sides should point to one another.
- Connect the two wafers together with the aid of the resistors as shown in Fig. 81b. The copper side of each wafer should face downwards. The resistors should be of the smallest commercial type to ensure a compact unit.
- Loop the power lines in between the two wafers (top right and underneath LD_1) with the aid of two short lengths of equipment wire as shown in Fig. 81c.

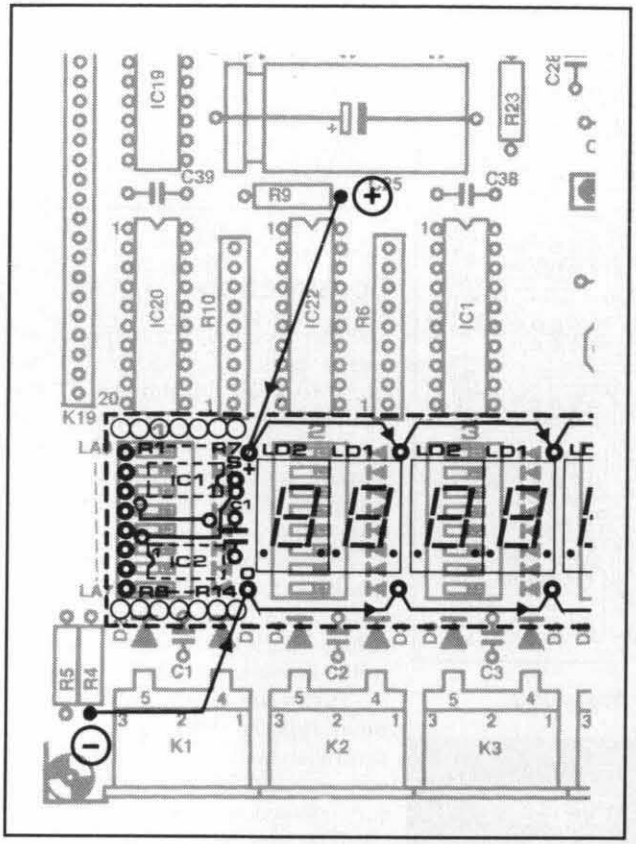


Fig. 82. Showing where connexions from the display unit are made on the mother board.

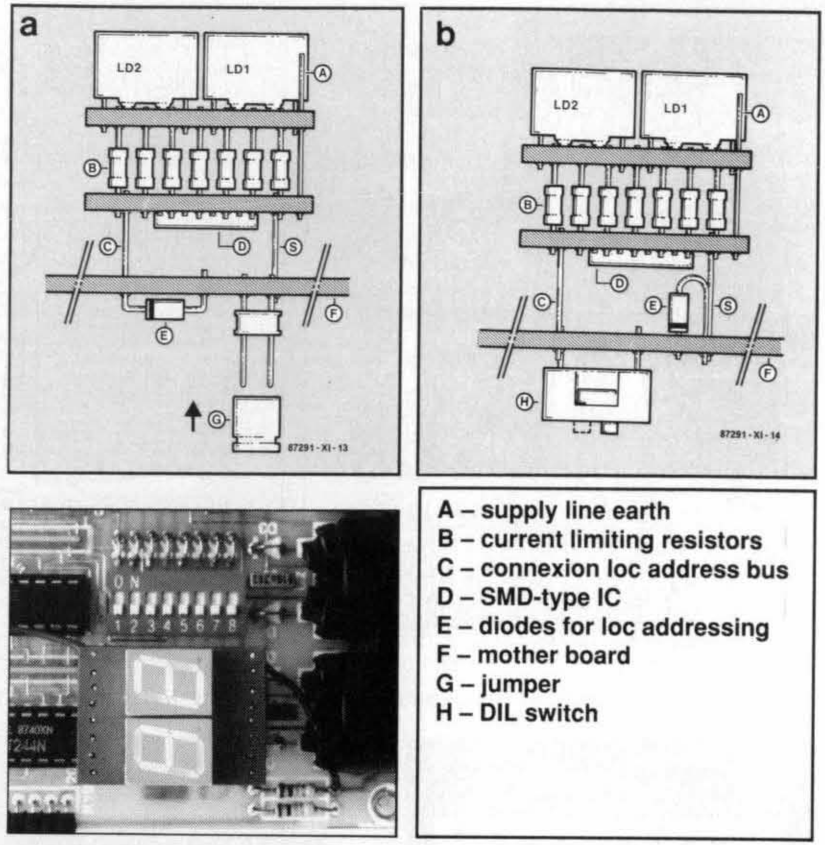


Fig. 83. Combination of an address display and hardware for setting locomotive addresses.

Interconnexions

Apart from the power lines, there are nine connexions between the address display and the mother board—see Fig. 82.

The power lines (0 V and +5 V) may be looped to other display units via lengths of normal equipment wire.

Each and every display unit may be used in conjunction with hardware for setting the locomotive addresses—see also "locomotive addresses" in Parts 7 and 8. If that is done, it is convenient to remove certain parts to the track side of the mother board. Two possibilities are shown in Fig. 83.

In the first (Fig. 83a), the eight diodes are fitted at the track side. The connexions to the cathodes may be used for connecting lines LA0–LA7 to the display unit. To make the whole easily removable, the display unit may be provided with a "semi IC socket". The setting of the loc addresses may be effected by fixed wire links or jumpers at the track side of the mother board.

The second design (see Fig. 83b) uses an 8-pole DIL switch at the track side of the mother board for setting the addresses.

Bear in mind that if an address is set by hardware, a locomotive controller can no longer be allocated an address via the serial interface. ■

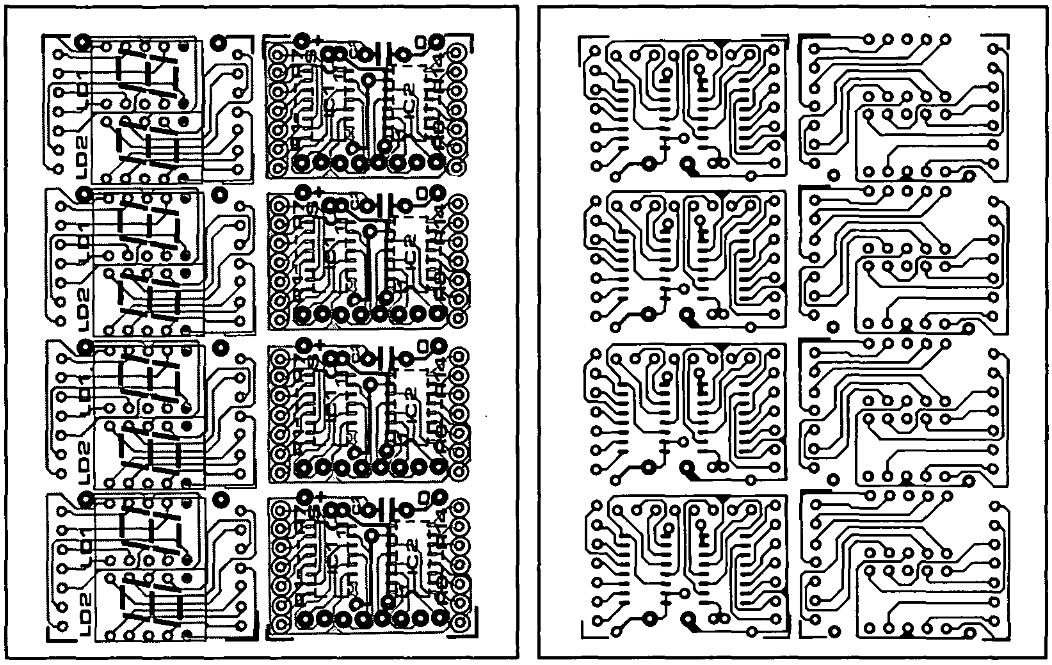


Fig. 80. The printed circuit board is designed for building up to four address display units.

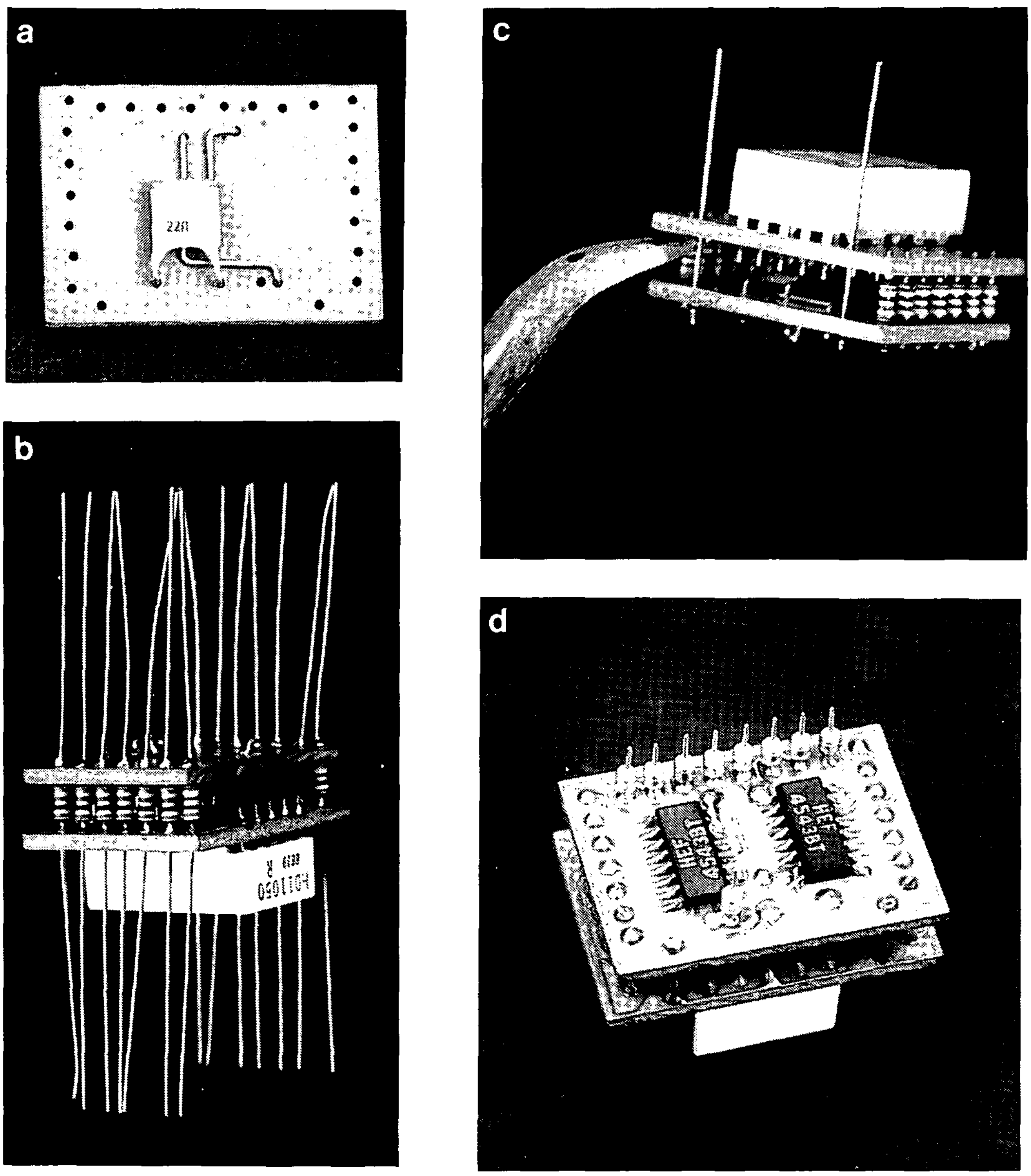


Fig. 81. Construction of the boards as a sandwich: 81a – the decoupling capacitor is laid flat on the board; 81b – through connexions are made with the aid of the resistors; 81c – the power lines are looped through; 81d – the sandwich is ready for connexion to the mother board.

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IC1, IC2 = 4543 (SMA type)
LD1, LD2 = HD1105 (red)
PCB 87291-9

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- Loop the power lines in between the two wafers (top right and underneath LD_1) with the aid of two short lengths of equipment wire as shown in Fig. 81c.

BBD SOUND EFFECTS UNIT

T. Giffard

Phasing, vibrato and reverberation are commonly used sound effects in modern music. The effects unit described here is a high-end piece of audio equipment that will make many musicians and sound engineers sit up. Based on a state-of-the-art bucket-brigade delay (BBD) chip, the unit is capable of many popular sound effects, including ADT, chorus, phasing and real-to-life reverberation.

Under normal circumstances, sound travels at a speed of about 340 m per second. This means that short echoes occur in relatively small rooms already, giving the so-called reverberation effect. Acoustic perception experiments have proved that the human ear is capable of detecting a sound delay as small as 5 ms only (corresponding to a distance of about 1.65 m). In particular, short reflections with their associated differences in regard of level, delay, and spectral composition create an impression of space with the listener.

Most electronic musical instruments are not based on sound created in a resonant cavity of any size or shape, and as a result produce a relatively 'flat' sound. Reverberation may be added by electronic means to add warmth to the sound of these instruments. In the present sound effects units, reverberation is achieved with the aid of adjustable degrees of feedback and attenuation, which results in a remarkably natural effect.

Bucket brigade delay

The drawing in Fig. 1 shows the basic set-up of an analogue delay line based on a bucket brigade memory. The memory is essentially a series of sample-and-hold circuits, each of which consists of electronic switches and capacitors. The analogue signals stored in the capacitors are sampled under the control of a central clock signal. At each clock pulse, the sample is shifted one capacitor to the right, hence the name 'bucket brigade' (the precursor of today's fire brigade).

After *n* clock pulses, the analogue signal is advanced *n* positions in the memory. A double clock is used to prevent the contents of two 'buckets' affecting each other as a result of the shift operation. Hence, clock 1 and clock 2 are in opposite phase.

To ensure acceptable distortion of the input signal as a result of the sampling operations, the clock frequency must be at least two times the highest frequency to be sampled (Nyquist's sampling theorem). A low-pass filter at the input of the bucket brigade delay limits the frequency range to a usable value. The output of the BBD chip also has a low-pass filter, in this case to remove the clock signal component.

Reverberation

Reverberation is an acoustic effect which occurs, in principle, in every room of which the walls have sound reflecting properties. The sound reflections are noted by generating a short acoustic sound burst, e.g., a hand clap. This sound will reach the ear directly as well as indirectly via reflections. The time it takes any reflection to reach the ear is in direct proportion to the time taken by the sound to reach the point where it is reflected. The amplitude of the reflection depends on the length of the path and the acoustic properties of the reflecting surface. Stone walls, for instance, absorb very little sound, whereas curtains have virtually no reflective properties. In many cases, sound reaches the listener via different paths. The amplitude of the reflections as a function of time is illustrated in Fig. 2.

The decay time is the time that lapses before a particular sound is so weak that it is no longer perceived. This parameter depends on the construction of the listening room and the materials used. A natu-

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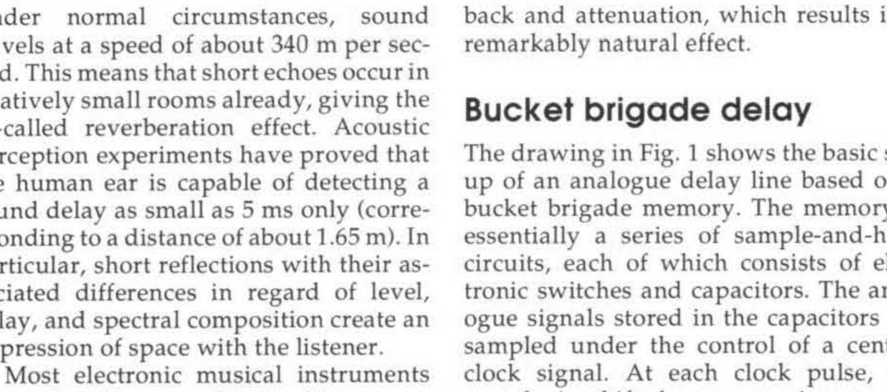

Fig. 1. Block diagram of the bucket-brigade sound effects unit.

ral sounding reverberation effect requires at least 1,000 reflections per second, which, as a further proviso, must reach the listener at a certain irregularity.

Reverberation: the electronic way

Figure 3a shows the simplest configuration of a reverberation unit based on controlled feedback. The associated amplitude-*vs*-time diagram is given in Fig. 3b. To achieve a decay effect, the amplitude of the reflections is reduced as a function of time with the aid of a voltage attenuator. In practice, the reverberation time, t, is defined as the time required to reduce the sound energy by a factor of 10^6 (60 dB). In Fig. 3a, this time may be calculated by counting the number of 'needle pulses' between the instant the sound is generated and the instant its amplitude is 60 dB smaller. Next, the number of needles is multiplied with the delay time, τ, of the reverberation unit, hence,

$$t = 60/\alpha\tau$$

where α is the attenuation per passage.

A practical example: a reverberation unit has an attenuation of 3 dB and a delay of 50 ms. An attenuation of 60 dB is, therefore, reached after 20 passages, each of which introduces a delay of 50 ms. The reverberation time, t, is 20×50 ms = 1 s.

In practice, reverberation times of the order of one or two seconds pose problems because they require an extensive (i.e., long) delay line. Acceptable results for reverberation times longer than about 0.5 s are only achievable with digital delay lines. Lower attenuation and a greater number of passes are usually not feasible in view of the risk of oscillation.

A second problem arises from the equal distances travelled by the generated reflections. Such a constant pattern can only occur in a spherical room, which, in the case of the above example (50-ms delay time) has a radius of 16.6 m. Evidently, such a room is at best rare in the real world.

An annoying side-effect of equally long t reflections is the creation of a comb-filter response—see Fig. 3c. At a delay of 20 ms, the distance between two peaks equals 100 Hz. The comb filter effect introduces a variation in the attenuation which is simple to calculate if the normal attenuation of the circuit is known. From the above example, a normal attenuation of 3 dB means that the signal is attenuated by a factor of 0.7 after a single passage through the reverberation unit. The variation in the attenuation owing to the comb filter effect is (1+0.7)/(1−0.7), i.e., 5.7 times or about 15 dB. Obviously, an amplitude ripple of 15 dB is not acceptable for hi-fi stereo applications. Yet, many reverberation units produced in the past

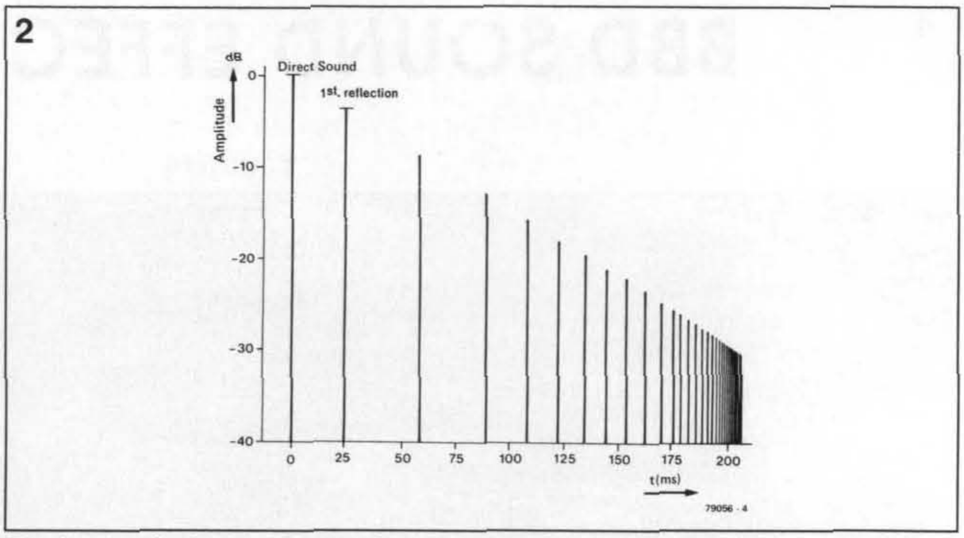

Fig. 2. Amplitude-time diagram of a pulse-shaped sound and the reflections caused by it.

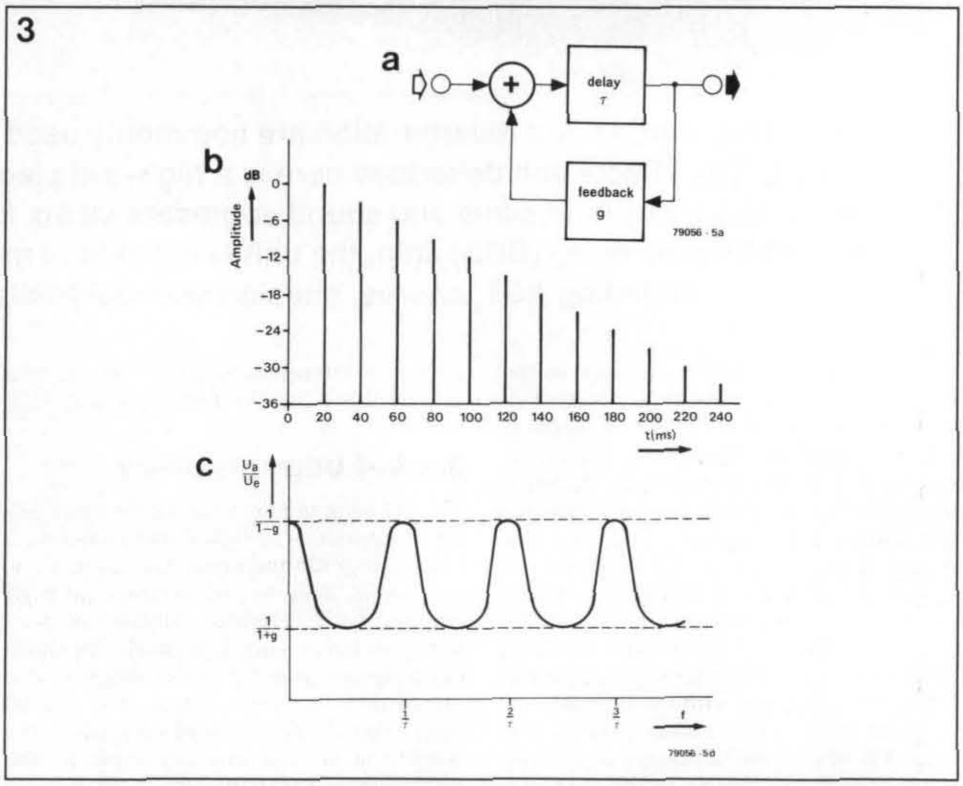

Fig. 3. Simplest configuration of a delay line with feedback (3a) and the associated amplitude-time diagram (3b). The frequency response of such a delay unit is not unlike that of a comb filter (3c).

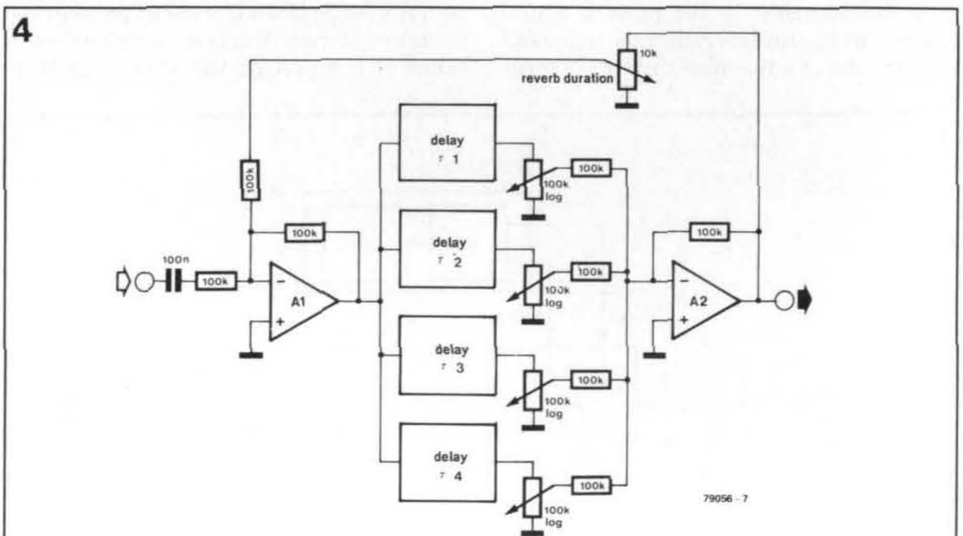

Fig. 4. Improved reverberation principle based on individually controlled delay lines.

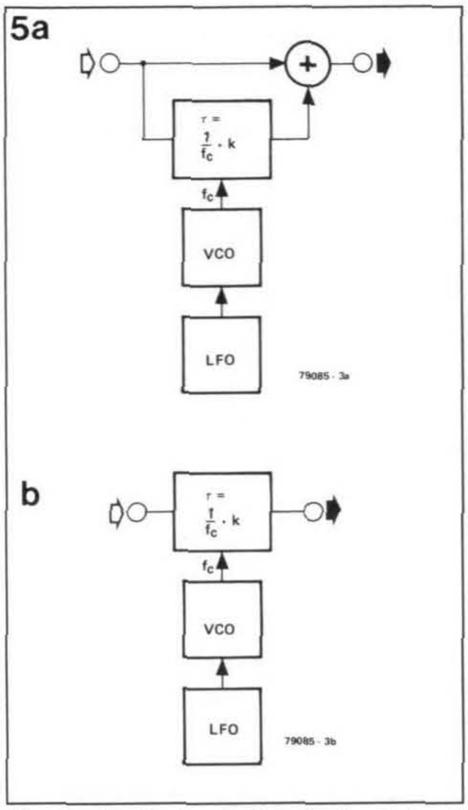

Fig. 5. Basic circuits for phasing (5a) and vibrato (5b).

used the above principle simply for lack of a better (electronic) alternative.

Multiple reverberation

A naturally sounding reverberation effect can only be achieved by using different delays of non-related durations. The block diagram of a reverberation unit based on this principle is shown in Fig. 4. From practical experiments, at least four delays are required for acceptable results. The sound effects unit described here has six different and non-related delays, while the attenuation for each of these is adjustable to give an optimum room simulation.

The delays used in the sound effects unit allow an estimate to be made of the size of the simulated room. A sound delay of 10 ms corresponds to a total path length of 3.3 m, or a wall distance of 1.65 m. The maximum setting, 100 ms, simulates a wall distance of 16.5 m.

Sound effects

The BBD sound effects unit offers a variety of sound effects which may be set to individual liking with a large number of controls. As examples, the degree of feedback for the delayed signals may be adjusted; the 'clean' (input) signal may be mixed with any one delayed signal. Furthermore, the unit allows a single delay to be used.

The **ADT-effect** (automatic double-tracking) is commonly used in modern music technology to give the sound more substance. Basically, the signal is briefly delayed (τ=1–5 ms) and then mixed with the original. If used in a multiple way, the result is the **Chorus-effect**. Here, the delay time is not constant but subject to small, irregular changes caused by modulation of the clock signal by a pseudo-random signal generator, for which the sound effects unit has an external input. The chorus-effect may use one or more delay lines in the unit, provided the output signal is not fed back to the input. The delayed signal is, therefore, simply added to the output signal.

Vibrato and **phasing** are based on modulation of the clock signal with a triangular, low-frequency, signal supplied by, for instance, an LFO (low-frequency oscillator). The vibrato-effect is obtained by using the delayed signal only, while for phasing the modulated as well as the delayed signal are added to the output signal. The different ways of generating these two sound effects are illustrated in Figs. 5a and 5b. The sound effects are rather different also. Strong vibrato brings to the mind a worn tape recorder or gramophone with speed regulation problems, while phasing is associated by many with the Hammond-effect based on doppler shift and achieved with the aid of rotating loudspeakers.

Phasing uses the previously mentioned comb-filter response that occurs at short delays (refer back to Fig. 3). The modulation of the clock signal shifts the points of maximum attenuation (poles) of the comb filter (Fig. 6) periodically, and so causes a spatial sound effect.

Both vibrato and phasing use delays smaller than 10 ms, which allows ready use of a BBD IC.

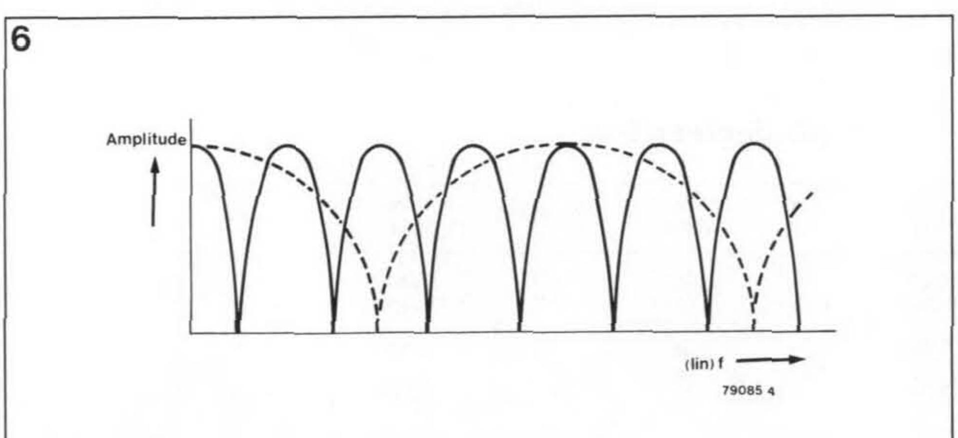

Fig. 6. Typical comb filter response of a delay line. The sound effect is 'phasing'.

MN3011/MN3101 BBD chip set

The Type MN3011 from Panasonic (a Matsushita company) contains a 3328-stage bucket-brigade delay line in PMOS technology. The pin-out and internal configuration diagram in Fig. 7 shows that six taps on the delay are bonded out to pins. The delay times associated with these pins are suitable for reverberation applications. The shortest reverberation time is available at pin 9, the longest at pin 4. The actual delay times achieved with the IC are determined by the frequency of the clock signals which are applied in opposite phase to pins 2 and 10. The maximum and minimum delay times at two clock frequencies, 10 kHz and 100 kHz, are given below:

BBD output (pin)	Delay at f_{cl}=10 kHz (ms)	Delay at f_{cl}=100 kHz (ms)
1(9)	19.8	1.98
2(8)	33.1	3.31
3(7)	59.7	5.97
4(6)	86.3	8.63
5(5)	139.5	13.95
6(4)	166.4	16.64

The operating voltage of the MN3011 is 15 V typical and 18 V maximum. At a supply voltage of 15 V, the current consumption is 8 mA typical. The direct voltage at the signal input must be adjusted for minimum distortion. Starting from a level of half the supply voltage, a potential change of up to 2 V may be necessary. The amplification of the BBD chip is 0 dB typical (unity gain), but may lie within 4 dB of this value. The maximum input level is stated as 1V_{rms} at 2.5% transient harmonic distortion (THD). At the nominal input level of 770 mV_{rms} (1 kHz), the THD is 0.4% typical.

A bandwidth of 10 kHz is achievable at a clock frequency of 40 kHz. From practical measurements on the chip, the noise level is between –70 and –72 dB at a clock of 40 kHz.

The pinning and internal configuration of the clock driver chip Type MN3101 are given in Fig. 8. External components are used to determine the clock oscillator frequency, which is divided by two and subsequently shaped to provide the opposite-phase clock signals for the MN3011. The MN3101 has an on-board voltage source that supplies about 14/15V_{dd}. This voltage is required for the BBD chip. The current consumption of the MN3101 is 3 mA typical at 15 V. ❑

The final part of this article will be published next month.

TEMPERATURE COMPENSATION FOR LCD MODULES

by M. Clarkson

Liquid crystal display (LCD) modules have grown in popularity over the past few years because they are easy to use and provide an attractive display. Unfortunately, they have a troublesome drawback: poor temperature compensation.This article shows a way of improving that.

LCD modules come in a variety of sizes: from one line of 16 characters to four lines of 20 characters. They contain all the necessary drive circuits, so that interfacing them with microprocessors is very simple—see Fig. 1.

Unfortunately, the poor temperature compensation of these devices makes it necessary, in order to ensure optimum contrast of the display, to vary the input signal from about 400 mV to 800 mV over the temperature range 0–50 °C. This signal variation may, of course, be obtained manually with the aid of a simple potentiometer, but a much neater way is automatic temperature compensation.

When I started on this problem, I first of all tried the circuit shown in Fig.2. This uses a darlington configuration to boost the temperature coefficient of the base emitter voltage and to reduce the required base bias current.

As the base-emitter voltage decreases with rising temperatures, the current in in R_1 drops. This reduces the voltage across R_2, which in turn increases the voltage across R_e and consequently the emitter current. Most of the emitter current flows in the collector circuit and thus as the emitter current increases, the voltage across R_c increases. It follows that the voltage across R_c is directly proportional to the temperature.

Assuming that the current in R_1 and R_2 is small compared with the current in R_e, we can show that the gain of the circuit is related to V_e:

$$i_1 = V_{be} / R_2 = V_b / R_2$$

and

$$i_2 = V_c / R_2 = V_e / R_e.$$

In both cases it is assumed that there is no base current.

$$dV_{be} / R_1 = di_1 \text{ or } dV_{be} = di_1 \times R_1,$$

in which dV_{be} is the change in base-emitter voltage with temperature.

Now,

$$dV_b = dV_{be} \times R_2 / R_1.$$

Since V_{be} is large compared with dV_{be}, it may be assumed that it is constant, so that $dV_b = dV_e$.

$$dV_e / R_e = di_e \qquad (i_e = i_c)$$

$$dV_{be} \times R_2 / R_e \times R_1 = di_c$$

Fig. 1. Graphical representation of a 4-digit LCD module.

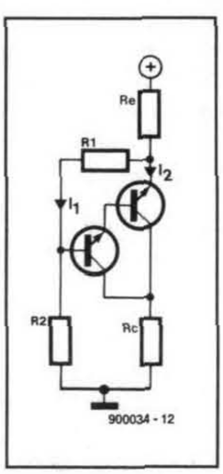

Fig. 2.

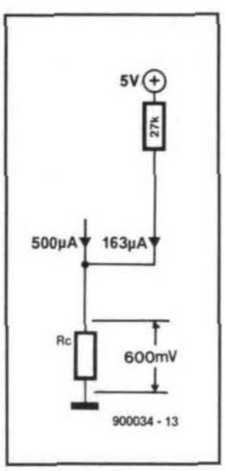

Fig. 3.

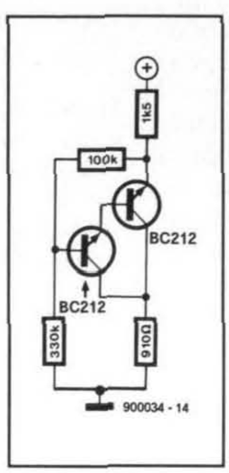

Fig. 4.

$$dV_c = dV_{be} \times R_2 \times R_c / R_1 \times R_e$$

$$dV_c / dV_{be} = A = R_2 \times R_c / R_1 \times R_e,$$

where A is the gain;

$$R_2 = V_b / i_1;\ R_1 = V_{be} / i_1;\ R_c = V_c / i_2$$

and $R_e = V_e / i_2$

Substituting, we obtain:

$$A = V_b \times V_c / V_e \times V_{be}$$

Since $V_b = V_{cc} - V_e - V_{be}$, this can be reduced to:

$$V_e = (V_{cc} - V_{be}) \times V_c / (V_{be} \times A + V_c)$$

With this equation we can estimate the required V_e and thus the resistor values required.

To calculate the emitter voltage we need to know the gain required and this is:

$$A = T_{e(R)} / T_{e(T)},$$

where $T_{e(R)}$ is the required temperature coefficient and $T_{e(T)}$ is the temperature coefficient of the transistor.

$T_{e(T)}$ of the darlington configuration is about 3.2 mV / °C owing to the small collector current (this causes a relatively large internal emitter resistance, which reduces the effective temperature coefficient of the base-emitter junction).

When using the circuit with an LCD module, you must take account of the 27 kΩ internal pull-up resistor—see Fig. 3.

With the Hitachi module , we require 600 mV at 25 °C. In Fig. 2 we see that with a current of 500 µA through the transistor and one of 163 µA through the internal resistor, the value of R_c will be

600 mV / 663 μA = 905 Ω. A practical value here is 910 Ω.

The 27 kΩ pull-up resistor means that the V_{cc} used in the equation is reduced by

$$910 / (27{,}000 + 910) \times V_{cc} = 163 \text{ mV}.$$

This makes $V_{cc} = 4.84$ V.

The V_{be} of the darlington pair is about 1 V with 500 μA flowing in the collector circuit, so that

$$V_{be} = (4.84 - 1) \times 0.6 / (1 \times 2.5 + 0.6) = = 0.743 \text{ mV}$$

Let $i_1 = 10$ μA, so that $i_e = 510$ μA at 25 °C. Then:

$$R_e = 0.743 \text{ mV} / 510 \text{ μA} = 1.46 \text{ kΩ};$$

$$R_1 = 1 \text{ V} / 10 \text{ μA} = 100 \text{ kΩ};$$

$$R_2 = (5 \text{ V} - 1.743 \text{ V}) / 10 \text{ μA} = 325.7 \text{ kΩ}.$$

The final circuit is shown in Fig. 4: the output from the prototype was linear over the temperature range of 0–50 °C. At 0 °C, $V_c = 425$ mV and at 50 °C, $V_c = 850$ mV. ■

SQUARE-WAVE GENERATOR

by M. Clarkson

Many circuits nowadays require a square-wave generator for which invariably a separate NE555 is used. Since many of such circuits frequently have an unused opamp or voltage comparator available, why not use that to build the square-wave generator?

If the circuit that requires a square-wave generator has a spare opamp or voltage comparator, the diagram in Fig. 1 may be used to realize the generator.

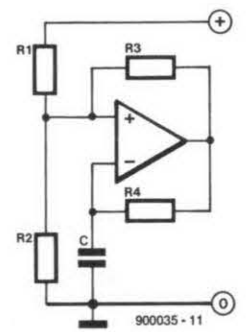

Fig. 1. Basic circuit of proposed square-wave generator.

The circuit works by capacitor C being charged and discharged to two different potentials created by R_1, R_2 and R_3. The time taken by C to reach the higher potential is the high period of the output, while that taken by C to discharge to the lower potential is the low period of the output.

To calculate the values of the circuit elements, we must simplify the circuit. Firstly, R_1 and R_2 can be reduced to their Thévenin equivalent as shown in Fig. 2.

When V_{out} is low, R_3 pulls V_{sense} to a lower voltage, V_{T-}. Capacitor C is then discharged via R_4 to the level of V_{T-}. When the potential across C, V_c, reaches V_{T-}, the output swings high. When V_{out} is high, R_3 pulls V_{sense} from V_{T-} to V_{T+}. Capacitor C then charges via R_4. As soon as V_c reaches V_{T+}, the output swings low and the cycle is completed.

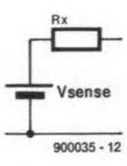

Fig. 2. Thévenin equivalent of R_1 and R_2.

If a spare opamp is used, the output frequency is limited to a range of 10 Hz to about 10 kHz, but this is sufficient for the majority of applications.

The two states of the circuit, ignoring R_4 and C, are shown in Fig. 3. The circuits in Fig. 3 enable us to calculate V_{T-} and V_{T+}:

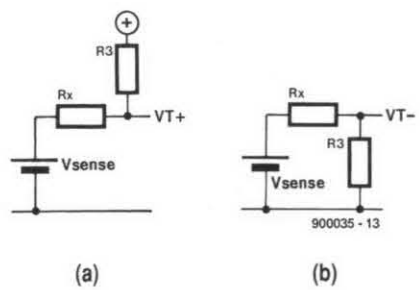

Fig. 3. The two equivalent states of the circuit: (a) ON state (C charges) and (b) OFF state (C discharges).

$$V_{T-} = V_s \times R_3 / (R_3 + R_x) \qquad [1]$$

$$V_{T+} = (V_+ - V_s) \times R_x(R_x + R_3) + V_s. \qquad [2]$$

So far I have assumed that the opamp requires no bias current—see Fig. 4. This is not true and, although the current is generally small, it can affect the circuit to quite an extent if R_1 and R_2 are too large. It is necessary that the current flowing through R_1 and R_2, that is, $V_c / (R_1 + R_2)$, is large compared with the bias current of the opamp.

I have also assumed that the output of the opamp swings between 0 V and $V+$. However, most opamps have a limited swing: if the one you use can not swing to within 10% of the supply voltage, you must take that into account in the calculations.

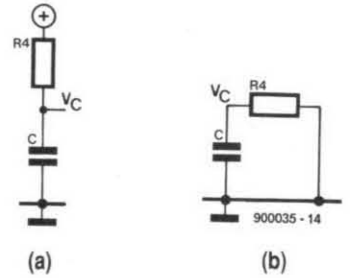

Fig. 4. The two states of R_4 and C: (a) ON state; (b) OFF state.

If, in Fig. 4., we make the difference between V_{T+} and V_{T-} small compared with $V+$, we may assume that C is charged and discharged at constant currents. The time, t, taken by a capacitor to charge at constant current is:

$$t = dVC / i, \qquad [3]$$

where dV is the voltage C has to charge to and i is the charging current.

The charging current is $(V_+ - V_c) / R_4$ and the discharge current is V_c / R_4.

If we want C to charge to V_{T+} and to discharge to V_{T-} in equal times, the charging and discharge currents must be equal, that is,

$$(V_+ - V_c) / R_4 = V_c / R_4, \qquad [4]$$

so that

$$V_c = V+ / 2 \qquad [5]$$

Voltage V_c is also equivalent to V_{sense}, that is, the mid-point between V_{T-} and V_{T+}.

To recap, I have said that the difference between V_{T-} and V_{T+} must be small compared with $V+$. This allows us to assume that a constant current flows through C.

Also, V_c must be equal to $V+/2$ to ensure that C is charged and discharged at the same rate.

Then, I have assumed that the output swings between 0 V and $V+$.

Furthermore, I have not taken into account the output resistance of the opamp. This is all right as long as R_3 and R_4 are sufficiently large.

Another aspect that must be borne in mind is the common-mode voltage, V_{cm}, of the opamp. As said, V_{sense} must be V_c / 2, which may be higher than V_{cm}.

Let us now calculate some circuit values: R_4 and C may be determined by deciding on the frequency, f, and the allowable charging current, i_c: $R_4 = V_c / 2i_c$, $f = 1 / T$, where $T = 2t$.

From [3] we obtain

$$C = it / dV.$$

In terms of frequency,

$$C = i / dV \times 2f, \qquad [6]$$

where dV is the difference between V_{T+} and V_{T-} and this must be small compared with $V+$. At the same time, it must be large compared with the offset voltage of the opamp. Since the offset voltage is usually about 5 mV, dV should be not less than 200 mV. It is calculated by subtracting [1] from [2], which yields:

$$dV = V+ \times R_x / (R_x + R_3). \qquad [7]$$

Since $V_{sense} = V_c = V+ / 2$, R_1 must be equal to R_2, so that $R_x = R_1 / 2$. From this it follows that

$$dV = V+ \times R_1 / (R_1 + 2R_3). \qquad [8]$$

The value of R_3 is then given by

$$R_3 = R_1 / 2\,(V+ / dV - 1) \qquad [9]$$

Resistor R_1 must be small enough to ensure that the current through R_1 and R_2 is large compared with the bias current, I_b, for the opamp, that is, $V+ / 2R_1 >> I_b$.

Let us now use a quarter of a Type LM339 voltage comparator as a practical example—see Fig. 5. The first thing to note is its open-collector output, which means that a pull-up resistor is required at the output. This resistor must be sufficiently small not to introduce any errors in our calculations.

The V_{cm} of the LM339 is greater than $V+$ / 2, assuming that $V+ = 5$ V. The bias current is around 0.25 µA, so that the current, i_c, through R_1 and R_2 may be set to 25 µA. We then obtain the folowing values:

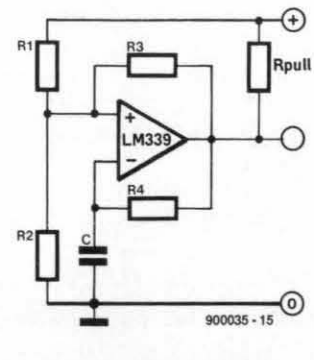

Fig. 5. Square-wave generator based on 1/4 Type LM339 voltage comparator

$$R_1 = V+ / 2i_c = 100\ k\Omega$$

$$R_2 = R_1 = 100\ k\Omega$$

Since the offset of the LM339 is <5 mV, we may take $dV = 200$ mV. Then, from [9],

$$R_3 = 1.2\ M\Omega$$

Assuming we want $f = 5$ kHz and a charging current, $i = 25$ µA, then, using [7], we obtain a value for C of 12.5 nF.

The value of R_4 is

$$R_4 = V_c / 2i_c = 50\ k\Omega.$$

When the output of the LM339 is high, the circuit in Fig. 6 may be used to calculate the optimum value of the pull-up resistor, R_{pull}.

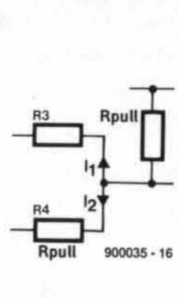

Fig. 6. Simplified circuit to calculate the voltage drop across R_{pull}.

If we allow a drop of 200 mV across R_{pull}, and taking into account that

$$i_1 = (V+ - V_c) / R_3 = 2\ \mu A \text{ and}$$

$$i_2 = (V+ - V_c) / R_4 = 50\ \mu A,$$

we obtain a value for R_{pull} of

$$R_{pull} = 200\ mV / (i_1 + i_2) = 200 / 52 = 3.8\ k\Omega.$$

In practice, the value may be reduced to, say, 2.2 kΩ and even further for low-impedance loads, but take care as the low output voltage of the LM339 may suffer.

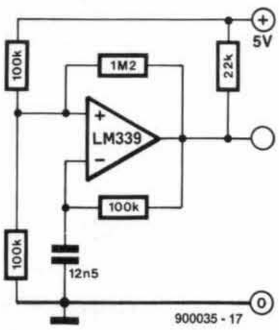

Fig. 7. Diagram of the final circuit of a 5 kHz square-wave generator.

The completed circuit is shown in Fig. 7. The prototype under test yielded a high period of 94 µs and a low period of 96 µs. The final frequency was 5263 Hz. It was calculated that the capacitor value should be 12.5 nF to give a frequency of 5208 Hz. Since a 12 nF type was used in the prototype, the actual frequency was rather higher, but well within satisfactory tolerance.

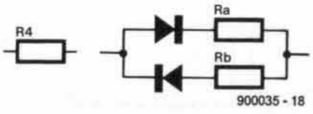

Fig. 8. Replacing R_4 by a resistor-diode network as shown enables the mark-to-space ratio of the output to be altered as required.

The high and low periods, that is, the mark-to-space ratio of the output voltage, may be varied by replacing R_4 by two resistors and two diodes as shown in Fig. 8. I shall leave the derivation to you. ■